Sage Policy Group, Inc.

Taking Montgomery County's Technology Community to the Next Level

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Synopsis

Based on an analysis of local market conditions and established long-term trends, the study team concludes that Montgomery County, MD should substantially augment its current supply of incubator space. This conclusion is driven by numerous County-specific factors, including:

- *the County's potential in numerous high-wage, high-tech segments;*
- *the local marketplace's demonstrated incapacity to provide an optimal level of laboratory space;*
- *the general lack of preparation among NIH, FDA, and other scientists/researchers in business management;*
- *the need to promote information flows between local scientists across multiple disciplines, including biotech/bioinformatics/biodefense, IT and nanotech;*
- *the desirability of multiple technology segment clustering in Montgomery County, which reinforces the sustainability and expansion of each individual cluster;*
- *the local funding gap; and*
- *similar regional competitor initiatives.*

An aggressive incubator-led strategy could boost Montgomery County's total job creation capacity by over 40 percent by 2020.

Executive Summary

<u>Factors Undermining Montgomery County's Tech Potential</u>

Montgomery County is second only to Silicon Valley in terms of its concentration of IT employment and anchors one of the largest clusters of biotech firms in the United States. Conservatively, there are roughly 555 high-tech startups per year in Montgomery County. To put this into perspective, at any given moment fully 16 percent of high-tech establishments in Montgomery County are start-ups; higher than the corresponding proportions in both Maryland and the U.S. This is astonishing given the multiple barriers to technology formation in Montgomery County uncovered by and analyzed in this report.

Montgomery County's lofty ranking is also remarkable given that the County remains in an early phase of biotechnology expansion. By 2000, the County's 15,000 biotech jobs comprised less than 3 percent of total jobs in the County, suggesting considerable room for expansion. SPG forecasts that biotech employment in Montgomery County will easily exceed 30,000 by 2020 under all conceivable circumstances and may exceed 50,000 by that time.

But for that to happen, Montgomery County must begin to address the obstacles that face scientific entrepreneurs in and out of the biotechnology sector. These impediments to innovation include: 1) market failure in the provision of wet lab space and other facilities required for research and development; 2) the lack of available financing for entrepreneurs; and 3) the lack of preparation among NIH, FDA, and other scientists/researchers in business management.

- Wet Lab Space and Market Failure

Our surveys generated unanimous agreement that Montgomery County faces a wet lab space crunch. Early stage companies face a significant shortage of sites offering 5,000 square feet or less. The Maryland Technology Development Center (MTDC) located at the Shady Grove Life Sciences Center is extraordinarily helpful in this regard, allowing biotech entrepreneurs access of space up to 3,200 feet. Beyond that range, facilities offering wet lab space in the 5,000-10,000 square foot range were described as “void”. Space under 5,000 square feet outside of the MTDC is almost impossible to find.

- The Funding Gap

Most analysts agree that Maryland and Montgomery County face substantial technology funding gaps. According to a 2001 report by Ernst & Young LLP, the Maryland bioscience industry faced a private venture capital funding gap of approximately $50 to $100 million per year by 2000-2001. The corresponding estimate of the venture capital funding gap in Montgomery County would be in the neighborhood of $35 to $70 million.

- Lack of Business Management Preparation

Despite their affinity for preparation, scientists as entrepreneurs experience quite a number of common difficulties during start-up and beyond. The great majority of scientific entrepreneurs are of the opinion that they were poorly prepared for entrepreneurship during university study. Once they become entrepreneurs, scientists often report being isolated from the broader scientific community, which not only compromises business success, but also slows innovation.

<u>Incubators as a Cornerstone of Montgomery County’s Tech Strategy</u>

Given the high correlation between innovation and prosperity, Montgomery County policymakers should seek to establish a comprehensive tech strategy that not only combats obstacles to entrepreneurship, but also fully exploits the dynamics of regional technology clustering. Our research indicates that incubators are a particularly useful economic development tool because their contributions are multi-faceted and directly counteract the impediments currently facing the County’s technology community.

Montgomery County is currently home to two publicly-financed incubators. The Maryland Technology Development Center (MTDC) in Rockville opened in 1999 and encompasses 57,000 square feet, 24 modular wet labs for biotechnology businesses, and 15,000 square feet for IT businesses. It is widely regarded as one of the nation’s most successful technology incubators. The County’s second incubator, the Silver Spring Innovation Center, opened in 2004 and was 70 percent full one month after opening. The potent demand for incubators stems from their relevance to the scientific and business communities.

- Incubators Provide the Right Facilities

Incubators provide the types of space required by scientists and undersupplied by the market. As an example, most of the smallest commercial spaces available in the leasing market tend to be larger than that required by startup biotech companies, which often mention 1,000 square feet as a desirable startup size. Published sources suggest that there is approximately 500,000 square feet of pent-up demand in Montgomery County, with less than 100,000 square feet available, most of which is functionally obsolescent and in need of substantial investment to meet current needs.[1]

Though estimating demand is highly speculative, our research suggests that start-up and early stage companies would likely be able to absorb at least 20,000 square feet of incubator space per year assuming appropriate marketing and leasing efforts. This figure is based on the average expected incubator tenants square footage requirements of between 1,400 to 1,500 square feet.[2] If just 2.5 percent of emerging technology companies in Montgomery County satisfy their need for space in incubators at some point in their early development, one arrives at the 20,000+ square foot figure.

Table E.1: Likely Annual Demand for Technology Incubator Space in Montgomery County, MD

Average Square Feet of Incubator Tenant	1,465.08
Estimated High-tech Start-ups per Year in Montgomery County	555
Annual Incubator Space Absorbed if 2.5% of Emerging Technology Companies Opt for Such Space	20,328
Annual Incubator Space Absorbed if 5% of Emerging Technology Companies Opt for Such Space	40,656

The provision of incubator space could also position Montgomery County for expansion in other tech segments, including information technology and nanotechnology. Nanotechnology represents a particularly beguiling opportunity. The goals of nanotechnology facilities differ somewhat from one to the next, and these differences tend to introduce some interesting facility design challenges. As an example, a project may involve placing viruses, which require biocontainment, on silicon wafers, which require cleanrooms. A biocontainment space requires negative pressure to combat intrusive contaminants. These two requirements are difficult to reconcile.

[1] MDBioNotes, Facilities Roundtable: Advance Planning is Key to Successful Expansion.
[2] This average was derived by analyzing incubator tenants at three Maryland incubators: MTDC in Rockville, the Silver Spring Innovation Center and the Chesapeake Innovation Center in Anne Arundel.

Therein is found Montgomery County's opportunity. Communities able to provide space to early stage nanotech companies may be able to quickly introduce clustering dynamics. We have documented elsewhere in this report the potential of nanotechnology, and the investments made by various states (e.g., New York) in promoting nanotechnology. Montgomery County has an opportunity to differentiate itself from local competitors by developing a nanotech strategy now. Moreover, nanotech clustering would support clustering in information technology and biotechnology.[3]

- Incubators Alleviate the Funding Gap

Incubators are also constructive in assisting early stage companies in preserving cash flow through the provision of competitive rents and business services, and in raising capital by helping entrepreneurs network with the venture community. But for its funding shortfall, the County could expect to experience additional job growth of 325 to 1,125 jobs per annum.

- Incubators Allow Entrepreneurial Businesses to Survive

Studies of technology incubators indicate that those best prepared to provide guidance and counseling to scientific entrepreneurs produced outsized results in the form of business survival and job creation. According to the Small Business Administration, four out of five new businesses fail within the first five years. However, the National Business Incubator Association estimates that 80 percent of firms cultivated in an incubator continue to operate after the same time period has elapsed.[4]

By the earlier part of the current decade, more measurements suggesting the success of business incubation came forward. The public sector cost per direct job created by investments in incubation is low, ranging from roughly \$3,000 to \$12,000 per job. Moreover, approximately 84 percent of incubated firms tend to locate locally upon graduation from an incubator.[5]

As business incubation has proliferated, research has sought to determine its effectiveness as an economic development tool. Campbell et al. (1988) concluded that incubators generated a public sector cost per direct job that ranged from \$3,500 to \$10,000. DiGiovanna and Lewis (1998) calculated that the average public sector cost per direct job created by six technology incubators in New Jersey was approximately \$3,000, significantly less than traditional industrial recruitment programs, which had an average public sector cost per job of over \$40,000.[6]

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[3] For further detail, please see Appendix B.
[4] Goldfisher, A., "Incubators Hatch Business Chicks", *The Business Journal*, August 5-11, 1996. More recent data indicate that the survival rate of incubated firms is roughly three times that of the general population of new enterprises. *See* Lewis, op. cit. at vii.
[5] Lewis, op. cit., at vii.
[6] DiGiovanna, S., & Lewis, D.A. (1998), *The Future of Technology Incubation in New Jersey: A Strategy for the New Jersey Commission on Science and Technology*, New Brunswick, MJ: Project on Regional and Industrial Economics, Rutgers University, at 6.

Other communities have come to appreciate the contribution of incubators, including Northern Virginia. Fairfax County's BioAccelerator was developed specifically to compete with Montgomery County for regional bioscience industry domination.

The Likely Implication of Expanding Incubator Capacity in Montgomery County

Based on our analysis, we conclude that Montgomery County could generate substantial economic impacts by augmenting its incubator capacity. Based on an extrapolation of the *Maryland Incubator Impact Analysis* prepared by RESI/Towson University in 2001, SPG calculated the likely impact of adding five properly managed technology incubators in Montgomery County. If one assumes that each of these incubators has been open for at least five years, Montgomery County could anticipate the following per annum future employment and personal income impacts presented in Table E.1.

Table E.2: Predicted Impacts of Five Additional Incubators in Montgomery County

Category of Impact	**Range of Predicted Impacts**
Direct Employment	2,427-2,586 jobs per annum
Total Employment (direct + indirect + induced)	4,485-4,758 jobs per annum
Direct Personal Income[7]	\$127.5-\$134.6 million per annum
Total Personal Income (direct + indirect + induced)	\$205.7-\$216.9 million per annum

Direct employment refers to the employment attributable to firms currently occupying incubators and to firms that have graduated from incubators and remained in Montgomery County. Total employment includes these direct jobs as well as their multiplier effect on the local economy.

Our results suggest that by the year 2020, these five incubators would have augmented Montgomery County's job creation capacity by 41.4 percent. Rather than adding a predicted 11,150[8] jobs per annum by the end of the next decade, we believe that Montgomery County could be expected to add approximately 15,770 jobs per annum with a sufficiently aggressive incubator strategy. We pause to note that the jobs directly supplied by incubated firms and graduate firms would pay substantially more than the prevailing County average given their high-tech status. In 2003 dollars, these jobs would pay \$67,184 on average. That compares to the prevailing County average annual wage of \$48,886.

[7] Personal Income is measured in 2004 dollars.
[8] This figure is estimated by analyzing average job growth in the County since 1996.

Introduction

Montgomery County, Maryland's largest and most technology driven jurisdiction, hired Sage Policy Group, Inc. (SPG)[9] through its Department of Economic Development (DED) to conduct an analysis of technology entrepreneurship in Montgomery County, MD. Specifically, SPG was asked to provide: 1) a snapshot of the level of technology entrepreneurship currently in the County across key industries; 2) the role played by federal government researchers in driving entrepreneurship and innovation; 3) the requirements of technology entrepreneurs with particular focus on facility needs; 4) the potential for biotechnology, information and nanotechnology industry growth and formation in the County; and 5) the need for government-sponsored incubator space to actualize the County's massive innovation potential.

In order to fulfill its obligations, SPG relied upon both primary and secondary research. SPG interviewed key decision-makers in the private and public sectors to determine the state of innovation in Montgomery County, its drivers and its impediments. In conducting its primary research, SPG interviewed numerous successful incubator graduates to determine the manner and extent to which incubation supported business growth and survival. SPG also spoke to those who work in the technology real estate and leasing sector of the economy to identify gaps in the provision of the types of space required by emerging technology companies. Particular attention was given to the extent to which wet lab space is provided adequately in Montgomery County.

SPG's secondary research involved compiling the finest and latest relevant literature. In conducting its literature review, SPG compiled literature focused upon six broad areas: 1) drivers of innovation and entrepreneurship; 2) the scientist as entrepreneur; 3) the financing requirements for successful technology business formation and survival; 4) the role of government policy in stimulating technology formation and diffusion; 5) the degree of success of technology incubators in spawning new companies and technologies in and out of Montgomery County, MD; and 6) best practices in business/technology incubation.

<u>Innovation = Prosperity</u>

The recognized role of policy in promoting technological change implies that policy should be utilized if one accepts the premise that innovation is correlated with prosperity. The term "new economy" has been used recently to describe the change of the global economy due to rapid advances in technology and innovation that have taken place in recent years. Information and communication technology have changed the nature of the workplace by contributing to more productive and efficient ways of conducting business, and improving the quality of products and services. Technology has also changed the way the global economy looks toward the future.[10]

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[9] Anirban Basu is the primary author of this study. He was ably assisted by SPG study team members Braedyn Woodring and Dave Thomas.

[10] Brown, B., (2003). *The "New Economy": Real or High-Tech Bubble?* Educational Resources Information Center.

One positive impact of this "new economy" and consequently the growth of high-tech employment is the increasing demand for highly skilled workers. An educated labor force has long been considered a key element for economic prosperity. Data indicate that areas with a more educated population tend to fare better economically than those that lack in educational attainment. The top ten counties in the nation for higher education (based on the percentage of people 25 years and older who have completed a Bachelor's Degree) tend to have lower unemployment rates than the U.S. average and even their corresponding state rates. Table 1 represents the Census Bureau's 2003 higher education rankings and unemployment rates by county with corresponding state and U.S. data.

Table 1-Higher Education Rank 2003 and Unemployment Rate by County, State and for the Nation, September 2004

Rank	County	Percentage of 25+ Population with Bachelor's Degree	Unemployment Rate, Sept. 04	Corresponding State Unemployment Rate, Sept. 04
United States		26.5%	5.4%	N/A
1	**Montgomery County, MD**	**57.4%**	**2.2%**	**3.9%**
2	Fairfax County, VA	56.3%	1.8%	3.3%
3	Boulder County, CO	56.0%	4.4%	5.0%
4	Howard County, MD	54.6%	2.5%	3.9%
5	New York County, NY	52.3%	6.6%	5.2%
6	Washtenaw County, MI	50.5%	3.2%	6.6%
7	Johnson County, KS	50.4%	3.8%	4.8%
8	Collin County, TX	48.8%	4.5%	5.6%
9	San Francisco County, CA	48.6%	5.3%	5.7%
10	Somerset County, NJ	48.2%	3.1%	4.7%

Source: U.S. Census Bureau; Bureau of Labor Statistics

With the exception of New York County, NY, all of the counties listed above have lower unemployment rates than the United States and their corresponding state.[11]

Moreover, high-tech jobs are also associated with higher wages. The national average annual wage for all occupations was $36,210 in 2003. The computer and mathematical sciences major occupational group had an average annual wage $27,030 higher than that of all occupations ($63,240 in 2003). Management occupations and legal services were

[11] The demand for skilled labor has pushed the need for higher education in the United States. The nation has seen an increase in undergraduate and graduate enrollment over the past decade, in part due to the increase in high-tech jobs and the demand for high-tech skills such as computer and database knowledge prevalent in this "new economy". In 2000, the nation had roughly 31 percent of the population 25 years and older with an Associate's degree or higher, up from 27 percent in 1990. The number of people with a Graduate or Professional degree increased 41 percent between 1990 and 2000.

the only major occupational groups reporting a higher mean annual wage. Specific high-tech occupations reported even higher annual wages. Table 2 below lists the average annual wage for select high-tech jobs in 2003.

Table 2-Average Annual Wage for Select High-Tech Jobs, 2003

Occupation	**Annual Mean Wage 2003**
Engineering managers	$100,490
Computer and information systems managers	$95,960
Computer and information scientists, research	$85,240
Computer hardware engineers	$82,040
Computer software engineers, systems software	$79,790
Biochemists and biophysicists	$70,100
Computer programmers	$65,170
Network systems and data communication analysts	$62,220
Graphic designers	$41,620
All Occupations	**$36,210**

Source: Bureau of Labor Statistics

High-tech employment promotes a wealthier, more educated workforce and society. Consequently, those regions of the nation that are very tech intensive tend to attract highly skilled and talented workers.

Not surprisingly, data suggest that metropolitan areas with the highest concentration of technology intensive jobs tend to also have higher migration numbers (into the area). A 2001 study by the Progressive Policy Institute (PPI) and the Center for Regional Economic Issues (REI) at Case Western Reserve University provides a ranking of metropolitan areas by the share of high-tech jobs to total employment in 1999.[12] Of the top 10 metropolitan areas on this list, all but one (San Francisco) had an equal or higher percentage of residents living in a different state in 1995 versus 2000 than the U.S. average (i.e. residents from other states migrated to these particular metropolitan areas). The top 10 metropolitan areas by high-tech job concentration and their corresponding percentage of migration from another state are presented in table 3 below.

[12] Atkinson, R. & Gottlieb, P. *The Metropolitan New Economy Index* (2001). Progressive Policy Institute.

Table 3-Top Metro Areas by Concentration of High-Tech Jobs, 1999, and Migration from a Different State, 1995-2000

Rank	Metropolitan Area	% of Workforce in High-Tech Jobs, 1999	% of Residents in 2000 Who Lived in a Different State in 1995
1	Austin, TX	9.0%	10.1%
2	San Francisco, CA	8.6%	6.8%
3	Raleigh-Durham, NC	8.0%	16.1%
4	Boston, MA	7.1%	8.4%
5	Denver, CO	5.1%	14.5%
6	Dallas, TX	5.0%	8.8%
7	San Diego, CA	4.9%	9.2%
8	**Washington, D.C.**	**4.8%**	**15.1%**
9	Minneapolis-St. Paul, MN	4.7%	8.7%
10	Portland, OR	4.5%	13.7%
United States Average		**3.1%**	**8.4%**

Source: Progressive Policy Institute; U.S. Census Bureau

Entrepreneurship and Innovation Drivers

The Scientist as Entrepreneur

Because of its concentration of federal lab researchers and technicians, the question of why scientists and related personnel leave publicly funded institutions for the private sector is of particular consequence to Montgomery County, MD. This section focuses on the factors that influence the decision of the scientist to transition from the not-for-profit to the commercial sector.

The literature focusing on the scientist as entrepreneur is expanding rapidly. For most of modern history, there has been an aversion to commercialization. This is because scientists have historically been guided by the notion of "disinterestedness", in which the researcher has no stake (at least no direct financial one) in the outcome of his/her research. Moreover, the norm of communality holds that a scientific advance is the property of the scientific community writ large, and that a contributor's entitlement to his/her discovery is limited to the recognition of his/her peers.[13] This norm has provided a steadfast foundation on which to base opposition to the privatization of institutional science.[14]

Consider, for instance, Derek Bok's early 1980s reflections on the normative and institutional risks of technology commercialization. He writes:

[13] Stuart, T. E. & Ding, W. W. (2004), *When Do Scientists become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences*, at 5.
[14] Id.

> " . . . commercial motives can introduce a . . . threatening form of secrecy. In order to maintain a competitive lead that could be worth large sums of money, scientists who engage in business may be tempted to withhold information until their discoveries can be further developed to a patentable state. Because the financial stakes are high, investigators may not merely withhold ideas from publication; they may become close-mouthed and refrain from the free, informal discussions with colleagues that are essential to the process of discovery." (1982, p. 150).

The breakthrough came because a few early pioneers began to enjoy success in the private sector. Because of the restricted distribution of opportunity during the 1970s, for instance, the most distinguished members of the scientific professions were the first to become involved in commercial ventures.[15] This helped to legitimize the "academic entrepreneur" designation, which has now achieved taken-for-granted status.[16]

Very recent findings support the view that top-most scientists are the ones most likely to transition to private activity. For instance, results indicate that scientists in top-20 universities are almost three times more likely to engage in commercial-sector science.[17]

Congress helped fuel the trend of scientists starting their own companies. In 1980, it passed the Bayh-Dole Act, a law designed specifically to accelerate the commercialization of academic discoveries. The Act encouraged universities to patent inventions and assign the rights to private companies that could commercialize them.

Today, *scientists are also most likely to become entrepreneurs when they have worked in departments in which colleagues have previously made the transition*.[18] This is particularly true when the individuals who had become commercialists were prestigious scientists.[19] Individuals with coauthors who had become entrepreneurs were also more likely to transition.[20]

These insights possess geographic relevance. Recent literature finds that physical proximity to adopters of commercial science also influence scientists' attitudes.[21] As early as 1951, Asch[22] found that the presence of just a small number of like-minded individuals greatly facilitated non-conforming behavior. In the context of this study, for the scientist who is intrigued by the commercial sector but is apprehensive about peer reaction, the company of just a few institutional/academic entrepreneurs may allay his/her

[15] Id. at 2.
[16] Id.
[17] Id. at 30.
[18] Id. at 3.
[19] Id.
[20] Id.
[21] Id. at 10.
[22] Asch, S. E., (1951), *Effects of Group Pressure upon the Modification and Distortion of Judgments*, 177-190 in H. Guetzkow (ed.), *Groups, Leadership and Men*. Pittsburgh: Carnegie Press.

concerns about the social repercussions of private sector transition.[23] Critically, spatial proximity to institutional entrepreneurs facilitates the formation of a reference group that condones the activity.[24] In other words, *entrepreneurs give rise to an entrepreneurial culture.*[25]

But it is not enough that scientists take the entrepreneurial plunge. Successful entrepreneurship is the objective, not entrepreneurship for entrepreneurship's sake. Though research in this area is limited, available findings suggest that scientists prepare themselves more thoroughly for entrepreneurship than others. Nearly 40 percent followed a specific course of entrepreneurship compared to only 6 percent of all start-ups in the Netherlands, for instance.[26] They also prefer to work within the context of a business plan, and view the business plan as an instrument for strategy development.[27]

Despite this affinity for preparation, scientists as entrepreneurs experience quite a number of common difficulties during start-up and beyond. *The great majority of scientific entrepreneurs are of the opinion that they were poorly prepared for entrepreneurship during university study.*[28]

These findings support the conclusions of a recent (2004) study prepared by Schachtel, et. al.[29] That study recommends that Maryland leaders "provide an open-armed experience for graduate students and post-doctoral and visiting fellows while they are in Maryland, exposing them if possible to some of the state's successful bioscience entrepreneurs".[30] This exposure serves to address the issue of scientist and entrepreneur, and to break down the perceived antipathy between scientific objectivity and commercialism.

The Schachtel report also recommends that Maryland leaders "work with universities and federal laboratories to identify and encourage interdisciplinary initiatives and research groups that are focused on the intersections of information technology and bioscience and health care".[31] This recommendation is consistent with the Jacobsian notion that innovation occurs not only within the context of individual, self-contained clusters, but across clusters.

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[23] Id.
[24] Id.
[25] This represents another benefit associated with incubators serving entrepreneurs. Entrepreneurship breeds itself.
[26] Poutsma, E. (1996), *Scientists as Entrepreneurs: The Importance of Entrepreneurial Districts*, at F.
[27] Id.
[28] Id.
[29] Schachtel, M., Bi, Y., & Kuklick, M. (2004), *The Genealogy of Maryland Information Technology Company Founders: Bioinformatics, Medical Informatics, Health Informatics*, Johns Hopkins Institute for Policy Studies.
[30] Id. at 5.
[31] Id.

Entrepreneurship and Capital Needs

Entrepreneurial firms have changing needs for capital at different stages of their development. Emerging firms are operating on potentially unreliable and uneven pools of resources while attempting to establish a product or service whose marketability and acceptability is uncertain. Initially these firms are likely to be unprofitable for a potentially long period, enduring continuous negative cash flows in the face of high start-up and initial operating costs (Van Bergen, 2004).

As entrepreneurial firms succeed in marketing their good or service, economies of scale result in declining costs of production, which in turn results in growth in profits as their good or service establishes itself in the marketplace. Van Bergen cites the example of the consumer electronics industry, where research and development leads to increasing economies of scale and efficiency of production. Yet the firm continues to enjoy increasing profitability even as prices for goods fall since costs of production fall more quickly (Van Bergen, 2004).

Potential investors analyze the position of an entrepreneurial firm strictly in terms of the risk faced and the potential return on investment. The following are commonly recognized as the typical stages of growth of new firms:

- **Idea stage**. Entrepreneurial firms at the stage of organizing and demonstrating a good or service in concept need seed capital. The investor may expect an inside role at this stage, facing an extremely high risk but also a potentially high return.
- **Research and development**. The company is founded through an initial investment by the founding officers. However, there is insufficient capital available for the fundamental research and development that is essential to bringing the product to a working prototype stage. Investors may be seeking a share of profits, stock in the company, or even a tax write-off.
- **Start up**. With a product prototype completed and tested, entrepreneurial firms may need capital to advance to a marketing stage, to finance market studies or further develop and refine a business or operating plan.
- **Expansion**. At this stage, entrepreneurial firms have a management team in place, and may be generating revenues though not profits. To facilitate expansion, however, entrepreneurial firms may need capital for inventory, advertising, or marketing.
- **Mezzanine**. At the mezzanine stage, the firm may be approaching a break-even point or even be profitable, but may need an infusion of capital for further expansion, marketing or other operating purpose, including some major corporate move.
- **Bridge**. At this stage, the firm may need short-term capital while making arrangements for other sources of financing.
- **Acquisition/merger**. The firm needs capital to finance a merger or acquisition of another firm.

- **Turnaround**. Following a difficult period during which a firm may slip from profitable to unprofitable, capital may be needed to initiate a reversal of fortune. Because the condition is the result of some underlying management or operating problem, the capital is likely to be targeted to extremely specific needs.

<u>The Local Funding Gap</u>

Most analysts agree that Maryland and Montgomery County face substantial funding gaps. According to a 2001 report by Ernst & Young LLP, the Maryland bioscience industry faced a private venture capital funding gap of approximately \$50 to \$100 million per year.[32] The corresponding estimate of the venture capital funding gap in Montgomery County would be in the neighborhood of \$35 million to \$70 million. This shortfall is significant, because the County could expect to experience additional job growth of 325 to 1,125 jobs per annum but for the funding shortfall.[33] Moreover, the funding gap exists for all funding amounts and is not being closed by current state government funding programs.[34]

Though there are government sources of funding for the biosciences and other leading edge industries, including SBIR grants, NIST funds for high-risk, high-payoff projects, NSF grants, and grants from TEDCO, certain Maryland state agencies and even local governments, there remains a dearth of funding availability.

This situation has pitted entrepreneur against entrepreneur. Recognizing the scarcity of funds, the Small Business Administration recently revised its Small Business Innovation Research (SBIR) Program by ruling that to qualify for a grant, a company must be at least 51 percent owned by "individuals" defined as excluding venture capitalists. Several Montgomery County biotechnology entrepreneurs and investors have stated that the ruling merely exacerbated a shortage of capital for biotech companies. Many Montgomery county biotechnology and information technology companies survive on SBIR grants dispensed by the National Institutes of Health, and restrictions on grant making can further limit commercialization potential.

This discussion merely reinforces the desirability of additional incubator space in Montgomery County. As is stated elsewhere in this study, incubators help firms secure financing by creating links to the venture community, and also help to preserve working capital through the provision of business services, flexible space, and competitive rents.

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[32] *Venture Capital Climate for Bioscience in Maryland*, Ernst & Young, December 2001, at i.
[33] Predicted job growth for the twelve months after the investments. Thereafter, job growth traceable to the original investment would be likely, but the magnitude of these job increases would be highly speculative. Therefore, the 325 to 1,125 job per annum estimate should be viewed as highly conservative. It should be noted, however, that these estimates do not incorporate the multiplier effect of jobs directly created via venture capital investments. The range is driven by possible assumptions one could make about how venture capital would be deployed, and the corresponding labor intensivity of activities. Average wages associated with these jobs would be elevated.
[34] Ernst & Young, op. cit., at ii.

Technology Entrepreneurship in Montgomery County and Maryland

New Business Formation

According to the U.S. Census Bureau, the average number of establishment births between 1999 and 2001 in the United States was 716,467 firms per year. The average number of total establishments during the same time period was roughly 7,057,931 per year in the United States. Therefore, approximately 10.2 percent of all establishments each year in the United States are new businesses. Table 4 below shows the average annual establishments, establishment births, and the percentage of establishments that are new in the United States by select high-technology sector. [35]

Table 4: Percentage of All Establishments that are New per Year in the United States (using 1999-2001 data)

Sector	**Average Births per Year**	**Average Establishments per Year**	**% of Establishments that are New**
Total	716,467	7,057,931	10.15%
Information	20,615	132,464	15.56%
Professional, scientific and technical services	83,296	721,310	11.55%
Health care & social assistance	53,532	659,925	8.11%

The Census Bureau also provides similar data for Maryland, which is presented in table 5 below. Maryland data are comparable to the United States, reporting approximately 10.0 percent of all establishments as new companies.

[35] New establishments/establishment births are defined as companies that have zero employment in the first quarter of the initial year and positive employment in the first quarter of the subsequent year.

Table 5: Percentage of All Establishments that are New per Year in Maryland (using 1999-2001 data)

Sector	**Average Births per Year**	**Average Establishments per Year**	**% of Establishments that are New**
Total	12,783	128,400	9.96%
Information	372	2,396	15.54%
Professional, scientific and technical services	1,973	16,593	11.89%
Health care & social assistance	1,041	13,170	7.90%

Although data on a county level is not available through the Census Bureau, the assumption can be made that the share of establishments that are new in Montgomery County is very similar to that in Maryland and the United States, given the fact that the state and the nation produce comparable data on the percentage of establishments that are new companies. Therefore, SPG applied the average share of establishments that are new in Maryland and the United States and applied those percentages to the annual average number of establishments by sector in Montgomery County to find the average number of new businesses for the county. The results are found in table 6 below.

Table 6: Percentage of All Establishments that are New per Year in Montgomery County (using 1999-2001 data)

Sector	**Average Births per Year**	**Average Establishments per Year**	**% of Establishments that are New**
Total	2,572	25,582	10.05%
Information	118	757	15.55%
Professional, scientific and technical services	594	5,065	11.72%
Health care & social assistance	235	2,937	8.01%

On an annual basis, Montgomery County experiences 2,572 new companies on average, with approximately 37 percent in the information, professional, scientific and technical services and health care and social assistance fields.

To better understand Montgomery County's annual high-technology entrepreneurship, more detailed industry classifications and related number of new establishments is needed. Currently no such official classification of high-tech industries exists. However, there have been studies to clarify and outline industries under the North American Industry Classification System (NAICS) and the Standard Industrial Classification (SIC) that can be considered as tech-intensive or that promote the advancement of technology (such as research and development). Two separate studies were used to classify high-tech industries.

The first study, *Maryland Innovation and Technology Index 2001*, produced by the Maryland Technology Development Corporation, outlined high-tech industries that were included in the SIC, which was the standard U.S. Department of Commerce classification system from 1930 through 2000. Please see Appendix for a detailed list of SIC high-tech industry codes.

For a more updated classification, a study from the Carnegie Mellon Center for Economic Development, titled *Technology Industries and Occupations for NAICS Industry Data*, was analyzed to obtain high-tech industry classifications included in NAICS from 2001 to the present. A total of 21 industries under the NAICS were classified as high-tech for this analysis. Please see Appendix for a detailed list of NAICS high-tech industry codes.

To analyze the number of entrepreneurs that have started businesses particularly in high-technology industries, SPG analyzed establishment births for the 21 industries listed in the above study for the United States. These data, provided by the Census Bureau, are presented below in table 7.

Roughly 14 percent of all classified high-tech establishments per annum are new companies. This compares to the 10 percent share of new businesses to all United States establishments, indicating greater new business formation in high-tech fields than in all other industries.

Specific high-tech industry data pertaining to establishment births is not available on the state or county level. However, given the similar shares of new establishments to total establishments between Maryland and the nation found earlier in this report, U.S. data can be applied to both the state and Montgomery County.

Table 7: Percentage of High-Tech Industry Establishments that are New per Year in the United States

NAICS Code	Description	Average Births 1999-2001	Average Establishments 1999-2001	% of Establishments that are New
2111	Oil/Gas Extraction	676	7,662	8.83%
3251	Basic Chemical Manufacturing	119	2,419	4.91%
3254	Pharm/Medicine Manufacturing	137	1,826	7.52%
3332	Industrial Machinery Manufacturing	284	4,542	6.25%
3333	Commercial/Service Industry Machinery Manufacturing	158	2,499	6.31%
3341	Computer/Peripheral Manufacturing	243	2,012	12.10%
3342	Communications Equip. Manufacturing	190	2,257	8.42%
3343	Audio/Video Equip. Manufacturing	58	553	10.42%
3344	Semiconductor/Electronic Manufacturing	449	6,086	7.38%
3345	Navigational/Electromedical Instrument Manufacturing	305	5,234	5.82%
3364	Aerospace Product Parts and Manufacturing	127	1,820	6.96%
4234	Prof./Commercial Merchant Wholesalers	*N/A*	*N/A*	*N/A*
5112	Software Publishing	1,136	10,695	10.62%
5161	Internet Publishing/Broadcasting	*N/A*	*N/A*	*N/A*
5179	Other Telecommunications	*N/A*	*N/A*	*N/A*
5181	Internet Service Providers/Web Search Portals	*N/A*	*N/A*	*N/A*
5182	Data Processing/Hosting and Related	*N/A*	*N/A*	*N/A*
5413	Architecture/Engineering and Related	9,779	103,106	9.48%
5415	Computer Systems Design and Related	18,423	98,265	18.75%
5416	Management, Scientific and Tech Consulting	15,782	98,548	16.01%
5417	Scientific Research and Development Services	1,689	12,747	13.25%
Total High-Tech per Year		**49,553**	**360,272**	**13.75%**

When the percentages of establishments that are new in the United States were applied to Maryland, SPG found that approximately 2,019 new high-tech companies are being established per year in the state. Full results are presented in table 8 below. [36]

[36] Establishment data for Maryland and Montgomery County for NAICS industry classifications are only available for 2001 and beyond. Therefore, to be consistent with Census data, high-tech industry establishments were only analyzed in 2001 for both the state and county.

Table 8: Percentage of High-Tech Industry Establishments that are New per Year in Maryland

NAICS Code	Description	Establishment Births 2001	Establishments 2001	% of Establishments that are New
2111	Oil/Gas Extraction	*N/A*	*N/A*	8.83%
3251	Basic Chemical Manufacturing	1.8	37	4.91%
3254	Pharm/Medicine Manufacturing	5.1	68	7.52%
3332	Industrial Machinery Manufacturing	3.4	55	6.25%
3333	Commercial/Service Industry Machinery Manufacturing	3.1	49	6.31%
3341	Computer/Peripheral Manufacturing	*N/A*	*N/A*	12.10%
3342	Communications Equip. Manufacturing	6.9	82	8.42%
3343	Audio/Video Equip. Manufacturing	*N/A*	*N/A*	10.42%
3344	Semiconductor/Electronic Manufacturing	6.6	89	7.38%
3345	Navigational/Electromedical Instrument Manufacturing	9.2	158	5.82%
3364	Aerospace Product Parts and Manufacturing	2.2	31	6.96%
5112	Software Publishing	10.0	94	10.62%
5413	Architecture/Engineering and Related	231.1	2,437	9.48%
5415	Computer Systems Design and Related	912.5	4,867	18.75%
5416	Management, Scientific and Tech Consulting	715.2	4,466	16.01%
5417	Scientific Research and Development Services	112.7	851	13.25%
Total High-Tech per Year		**2,019.8**	**13,284**	**15.20%**

Note: Industries that did not provide data for the U.S. are not included in the table above.

The share of high-tech establishments that are new in Maryland is roughly 15 percent per year, slightly higher than the nation's 14 percent share.

The above percentages of all high-technology establishments that are new businesses were also applied to corresponding Montgomery County data. The results are presented in table 9 below.

There are roughly 555 new high-tech start-ups per year in Montgomery County. This represents approximately 27.5 percent of the state's 2,020 new high-tech companies per year. To put this into perspective, at any given moment fully 16.0 percent of high-tech establishments in Montgomery County are start-ups. This is higher than the corresponding proportions in both Maryland and the US.

The number of new establishments in Montgomery County is understated because data for many high-technology industries were unavailable.

Table 9: Percentage of High-Tech Industry Establishments that are New per Year in Montgomery County

NAICS Code	Description	Establishment Births 2001	Establishments 2001	% of Establishments that are New
2111	Oil/Gas Extraction	*N/A*	*N/A*	8.83%
3251	Basic Chemical Manufacturing	*N/A*	*N/A*	4.91%
3254	Pharm/Medicine Manufacturing	0.7	9	7.52%
3332	Industrial Machinery Manufacturing	*N/A*	*N/A*	6.25%
3333	Commercial/Service Industry Machinery Manufacturing	0.3	5	6.31%
3341	Computer/Peripheral Manufacturing	*N/A*	*N/A*	12.10%
3342	Communications Equip. Manufacturing	2.3	27	8.42%
3343	Audio/Video Equip. Manufacturing	*N/A*	*N/A*	10.42%
3344	Semiconductor/Electronic Manufacturing	1.1	15	7.38%
3345	Navigational/Electromedical Instrument Manufacturing	2.0	34	5.82%
3364	Aerospace Product Parts and Manufacturing	*N/A*	*N/A*	6.96%
5112	Software Publishing	3.5	33	10.62%
5413	Architecture/Engineering and Related	50.4	531	9.48%
5415	Computer Systems Design and Related	250.3	1,335	18.75%
5416	Management, Scientific and Tech Consulting	204.0	1,274	16.01%
5417	Scientific Research and Development Services	40.7	307	13.25%
Total High-Tech per Year		**555.2**	**3,570**	**15.55%**

Note: Industries that did not provide data for the U.S. are not included in the table above.

Scientists as Entrepreneurs in Montgomery County

Although there is a general view that many high-tech entrepreneurs in the nation and Montgomery County have transitioned from the federal or academic sector, no official data on this subject currently exists. However, high-tech employment trends in the public versus private sector suggest that there has been a recent move from the public to the private sector, especially in Maryland and Montgomery County.

For example, the high-tech industry with the largest and most documented concentration in employment in both the public and private sector is the scientific and research development sector (NAICS code 5417). Employment in this industry has steadily increased in the U.S., Maryland and Montgomery County, yet employment trends differ between the public and private sector.

In the United States:

- Employment in scientific/research services grew 13.4% between 2001 and 2003 for the federal government.
- Employment in scientific/research services grew 0.71% between 2001 and 2003 for the private sector.

In Maryland:

- Employment in scientific/research services grew 73% between 2001 and 2003 for the federal government.
- Employment in scientific/research services grew 9% between 2001 and 2003 for the private sector.

In Montgomery County:

- Employment in scientific/research services **declined** by 2.7% between 2001 and 2003 for the federal government.
- Employment in scientific/research services **grew** 17% between 2001 and 2003 for the private sector.

The fact that Montgomery County was the only area where scientific and research development employment for the public sector declined suggests that in Montgomery County, a higher proportion of scientists and researchers that have worked in a federal setting have moved to the private sector.

<u>The Foreseeable Future of Technology in Montgomery County</u>

- Biotechnology

Montgomery County's existing pool of biotech companies and its supply of human capital (e.g., 10,000 scientists at NIH) effectively guarantee the County a large and substantial role in biotechnology going forward. The question therefore is the potential for the industry for further expansion and wealth creation.

Importantly, the US government supports the largest share of the world's biotechnology research, much of which is performed by NIH. The NIH is comprised of 18 institutes including the National Human Genome Research Institute, the National Cancer Institute, and the National Institute of Allergies and Infectious Diseases. Additionally, the Walter Reed Army Institute of Research and the Uniformed Services University of Health Sciences have active vaccine research and therapeutic drug development programs aimed at protecting the US armed forces from infectious diseases. The National Institute of Standards and Technology (NIST) in Gaithersburg incorporates a Biotechnology Division with a mission to advance the commercialization of biotechnology. NIST and the University of Maryland have jointly formed the Center for Advanced Research in Biotechnology (CARB) at the Shady Grove Life Sciences Center.

The County has developed an extensive plan to promote biotech. In the early 1980s, the County developed the Shady Grove Life Sciences Center, a 288-acre park owned and operated by the County and specifically zoned for research and development.

In January 1999, the County opened the Maryland Technology Development Center, a 50,000 square foot incubator for start-up biotech and info tech companies at the north end of the Life Science Center. Since December 1999, MTDC has been effectively 100 percent occupied.

Based on its growing presence in human genomics and bioinformatics, Montgomery County is in an early phase of biotechnology expansion. By 2000, the 15,000 biotechnology jobs comprised less than three percent of total jobs in the County. SPG forecasts that biotech employment in Montgomery County will easily exceed 30,000 by 2020 under all conceivable circumstances, and may exceed 50,000 by that time.

- Information Technology

The Bureau of Labor Statistics projects the IT industry to be the fastest growing sector of the economy over the next 8 years, with 7 of the 30 fastest growing occupations expected to be IT related. The rapid growth in IT projected for the United States disproportionately benefits Montgomery County, given its IT assets.

According to the Montgomery County Department of Economic Development, roughly 35 percent of Maryland's IT companies are located in Montgomery County, making it second in the nation in terms of the concentration of technology employment next to California's Silicon Valley.[37] In 2003, Montgomery County was ranked the third "digital" county of all U.S. counties with a population of 500,000 or greater; the ranking analyzes efficiency and production in a region's government use and implementation of information technology resources.[38]

Montgomery County's two high-tech corridors support numerous IT companies and create a technology cluster that sets the county up for even more IT potential in the future. The I-270 Corridor encompasses Bethesda, Rockville and Gaithersburg and features companies such as Lockheed Martin, The National Association of Securities Dealers and Hughes Network Systems. The other high tech corridor, Silver Spring/Route 29, is located in the eastern part of Montgomery County and is the home of companies such as Discovery Communications and Verizon.

- Nanotechnology

According to the National Science Foundation, nanotechnology will open a $1 trillion market in 10-15 years and expand the worldwide workforce by at least 2 million people in application spaces ranging from manufacturing to electronics, pharmaceuticals, healthcare, chemicals and transportation. The US government, through the national

[37] Montgomery County Department of Economic Development.
[38] The Center for Digital Government; National Association of Counties.

Nanotechnology Initiative (NNI), has allocated over $800 million to nanotechnology in its FY2004 budget. It proposes to spend $3.7 billion over the next four years to fund nanotechnology R&D through the recently enacted 21st Century Nanotechnology Research and Development Act.

Maryland is ranked sixth in nanotechnology nationally according to *SmallTech*, the leading new magazine of the nanotech industry. The states ranked ahead of Maryland are California, Massachusetts, New Mexico, Arizona and Texas. New York, Illinois, Michigan and Pennsylvania round out the top ten.

Of these states, New York may be the one to watch. Sematech International, a consortium of the world's 12 major computer chip manufacturers, will site its computer chip and development center in Albany, New York. Albany is not known as a hotbed of technology, just state politics. But Forbes has observed that "New York's Albany region could become the Silicon Valley of nanotech and even surpass it in economic performance."

Table 10: Top 10 States to Watch for Nanotechnology, 2002

Rank	**State**
1	California
2	Massachusetts
3	New Mexico
4	Arizona
5	Texas
6	**Maryland**
7	New York
8	Illinois
9	Michigan
10	Pennsylvania

New York has neatly positioned itself to be the nation's long-term nanotech leader. Governor George E. Pataki has announced more than $150 million in public and private sector support for a Center of Excellence in Nanoelectronics at SUNY Albany, with considerable support from IBM. This funding comes on top of the NSF's recent decision to award a number of New York universities contracts to construct nanotechnology science and engineering centers.

If Maryland wants to be a nanotech leader, it needs to watch New York carefully. Already, the state appears ready to mimic New York, albeit on a smaller scale. The University System of Maryland plans to seek $24 million from the State this year to further nanotechnology research and attract scientists to the area. The plan calls for $8 million a year from the State for fiscal years 2006-2008, coupled with $100 million in federal and private funding.

The Facility Needs of Montgomery County's Scientific Communities

- Biotechnology

Our surveys generated unanimous agreement that Montgomery County faces a wet lab space crunch. Early stage companies face a significant shortage of sites offering 5,000 square feet or less. The Maryland Technology Development Center (MTDC) located at the Shady Grove Life Sciences Center is helpful in this regard, allowing biotech entrepreneurs access of space up to 3,200 feet. Beyond that range, facilities offering wet lab space in the 5,000-10,000 square foot range were described as "void". Space under 5,000 square feet outside of Shady Grove is almost impossible to find.

Most of the smallest commercial spaces available in the leasing market tend to be larger than that required by startup biotech companies, which often mention 1,000 square feet as a desirable startup size. Published sources suggest that there is approximately 500,000 square feet of pent-up demand in Montgomery County, with less than 100,000 square feet available, most of which is functionally obsolescent and in need of substantial investment to meet current needs.[39]

Our interviews were highly supportive of policy decisions that would increase the amount of wet lab space in the County. The general feeling was that the marketplace is simply not prepared to provide space at appropriate scale, and that additional life science incubators could help to partially alleviate the condition. The explanation for this is reasonably straightforward. The costs of finishing and equipping a wet lab range from $100 to $150 per square foot for typical lab space[40] and up to $1,200 for highly specialized space such as clean rooms. This compares to roughly $15 per square foot for average low-rise office interior finish.[41]

With respect to the incubator in Rockville, three separate interviewees confirmed that demand for space greatly exceeds supply. According to the latest information available, the MTDC is 100 percent occupied and a wait list exists. This is in part a reflection of market forces that virtually guarantee a shortage of wet lab space in the County.

Financing of wet lab space is inherently risky not only because of its phenomenally high cost, but because the profitability of new drug development can be highly speculative and the prospects of firm failure high. Traditional institutional lenders are said to be uninterested in this type of project because it falls short of risk standards. Moreover, wet lab space is not yet built on speculation, and biotech firms requiring new space therefore face a perpetual hunt for space offering appropriate square footage.

Our interviewees also supported recent literature that is consistent with the notion that many bioinformatics firms use computers as their primary tools and have little if any need for lab space. In fact, these firms primarily use office buildings, and if

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[39] MDBioNotes, Facilities Roundtable: Advance Planning is Key to Successful Expansion.
[40] Hedgpeth, D., "At a Loss for Laboratory Space", *Washington Post,* March 6, 2000.
[41] R.S. Means, Square Foot Costs, 1999.

bioinformatics is included in the biotechnology sector, roughly as many Montgomery biotech firms are in office buildings as in flex buildings.

This, however, does not rule out the desirability of a bioinformatics incubator in Rockville. As with all early stage companies, bioinformatics firms will need to preserve working capital, and will benefit with contact with potential customers and financiers. Moreover, a bioinformatics incubator will help to promote the clustering dynamics that lie at the heart of economic development theory today.

- Nanotechnology

There are many aspects of nanotechnology research. They include theoretical studies, modeling, surface characterization, development of equipment for nano-scale manipulation, atomic manipulation and nano-scale manufacturing.[42] These branches require vastly different physical environments, which suggests that the facility requirements for nanotech clustering may be much more complex than those associated with biotechnology. It is true, however, that the least demanding work may be performed in a conventional office environment. The most demanding will require clean space, thermal stability, and quite acoustic and vibration background.[43]

It has been said that this range of physical demands is similar to those presented by semiconductor R&D. However, semiconductor research is frequently incorporated into large facilities where relevant functions can by physically and appropriately separated.[44]

Many sensitive tools used in nanotechnology have tool-specific vibration requirements. However, there are a number of reasons that specific design for individual tools is undesirable. In particular, new tools are likely to be introduced over the life of the facility.[45]

As a result, it has become common practice to use a limited set of published "generic" vibration criteria that may be selected for a facility or space within a facility based upon the most demanding equipment likely to be used in a given process.[46]

For those considering the development of a nanotech incubator, this makes life rather complex. The goals of nanotechnology facilities differ somewhat from one to the next, and these differences tend to introduce some interesting facility design challenges.[47] As an example, a project may involve placing viruses, which require biocontainment, on silicon wafers, which require cleanrooms. A biocontainment space requires negative

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[42] Amick, H., Gendreau, M., & Gordon, C.G., *Facility Vibration Issues for Nanotechnology Research*, Presented at Symposium on Nano Device Technology 2002, May 2-3, 2002, National Chiao-Tung University, Hsinchu, Taiwan, at 1.
[43] Id.
[44] Id.
[45] Id. at 2.
[46] Id.
[47] Id.

pressure to combat intrusive contaminants. We are told that these two requirements are difficult to reconcile.[48]

But therein lies the opportunity for Montgomery County. We suspect that communities able to provide space to early stage nanotech companies may be able to quickly introduce clustering dynamics. We have documented elsewhere in this report the potential of nanotechnology, and the investments made by various states (e.g., New York) in promoting nanotechnology. Montgomery County has an opportunity to differentiate itself from local competitors by playing a nanotech strategy now. Moreover, according to the Jacobsian view of the world, nanotech clustering would support clustering in information technology and biotechnology.

Though estimating demand is highly speculative, our research suggests that start-up and early stage companies would likely be able to absorb at least 20,000 square feet of incubator space per year assuming appropriate marketing and leasing efforts. This figure is based on the average expected incubator tenants square footage requirements of between 1,400 to 1,500 square feet.[49] If just 2.5 percent of emerging technology companies in Montgomery County satisfy their need for space in incubators at some point in their early development, one arrives at the 20,000+ square foot figure.

Table 11: Likely Annual Demand for Technology Incubator Space in Montgomery County, MD

Average Square Feet of Incubator Tenant	1,465.08
Estimated High-tech Start-ups per Year in Montgomery County	555
Annual Incubator Space Absorbed if 2.5% of Emerging Technology Companies Opt for Such Space	20,328
Annual Incubator Space Absorbed if 5% of Emerging Technology Companies Opt for Such Space	40,656

The Degree of Success of Technology Incubators in Spawning New Companies and Technologies

Technology business incubators became a popular economic development strategy in the US beginning in the late 1980s due to the confluence of a number of factors. These factors include: 1) massive restructuring of the economy, particular in the goods producing sector; 2) the evolution of innovation theory; 3) the emergence of technopoles; and 4) new insights regarding the role of small businesses and entrepreneurialism in the expansion of the US economy.[50] Policymakers understood then and understand now that the vast majority of new enterprises failed as a result of three common and persistent

[48] Id.

[49] This average was derived by analyzing incubator tenants at three Maryland incubators: MTDC in Rockville, the Silver Spring Innovation Center and the Chesapeake Innovation Center in Anne Arundel.

[50] Lewis, D.A., (2001), *Does Technology Incubation Work? A Critical Review*, Reviews of Economic Development Literature and Practice: No. 11, at vii.

problems: lack of capital, poor managerial skills, and insufficient understanding of the marketplace.[51]

Incubators strive to counter these obstacles to business survival. How they do this is discussed below, but the broad outcomes are clear. According to the Small Business Administration, four out of five new businesses fail within the first five years. However, the National Business Incubator Association estimates that 80 percent of firms cultivated in an incubator continue to operate after the same time period has elapsed.[52]

By the earlier part of the current decade, more measurements suggesting the success of business incubation came forward. The public sector cost per direct job created by investments in incubation is low, ranging from roughly $3,000 to $12,000 per job. Moreover, approximately 84 percent of incubated firms tend to locate locally upon graduation from an incubator.[53]

In response to positive outcomes, state and local economic development officials have embraced the creation of business incubators. The commonly accepted birth data for business incubation in the US is 1959, when the far-sighted citizens of Batavia, New York, in conjunction with their local government, responded to the loss of a major manufacturing plan by establishing a mixed-use incubator in one of the abandoned buildings.[54]

In the 1970s and 1980s, other Northeastern communities responded to their own economic deindustrialization crises by establishing incubators. Between 1975 and 1985, the number of incubators rose from approximately 20 to roughly 150 nationwide.[55] Between 1986 and 1996, the population nearly quadrupled to 548.[56] By 2001, the count had grown to approximately 900 incubators in the US. Two years later, and the total approached 1,000.[57]

In theory, technology incubators stimulate the innovation process by linking technology development with market demands, while providing capital for innovation, particularly in startup enterprises deemed too risk for many investors (particular in down periods of the venture cycle).[58] The benefits of public sector support of technology incubation include: 1) increased pace of new job formation; 2) generation of an entrepreneurial spirit that results in new firm formation and increased private investment in innovation; and 3)

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[51] Id.

[52] Goldfisher, A., "Incubators Hatch Business Chicks", *The Business Journal*, August 5-11, 1996. More recent data indicate that the survival rate of incubated firms is roughly three times that of the general population of new enterprises. *See* Lewis, op. cit. at vii.

[53] Lewis, op. cit., at vii.

[54] Id. at 7.

[55] Id. at 7.

[56] Id. at 1.

[57] Lalkana, R., *Technology Business Incubation: Role, Performance, Linkages, Trends*, National Workshop on Technology Parks and Business Incubators, Isfahan, Iran, May 2003.

[58] Lewis, op. cit. at 4.

greater incentives for highly skilled individuals (i.e. the creative class) in the host region.[59]

Moreover, industrial innovation, whether product or process, can generate first mover benefits to the innovating firm. This in turn can lead to new agglomerations of technology, increasing the prospect for additional wealth generation in the host region.[60]

Marketplace failures addressed by the business incubation process include restricted capital flows, lack of technology transfer, and unequal access to and cost of information.[61] Many mainstream economists, including this study's primary author, suggest that there is an undersupply of capital in regard to investment in new technologies.[62] It is also well documented that undercapitalization of small startup firms is a primary reason for failure, legitimizing state action in the incubation process.

The theory of business incubation also holds that public sector assistance to early stage enterprises will catalyze a spirit of entrepreneurialism, improving the general business climate.[63] This improved business climate attracts private investment capital into the region, and in the context of technology incubation, increases investment in emerging technologies.[64] In turn, these emerging technologies generate additional spillovers, improving the business climate yet further and reigniting the economic growth momentum anew.

There are a variety of ways that technology incubators provide economic resources including: 1) below-market rent for physical space with basis equipment; 2) access to sophisticated equipment at nor or reduced cost; 3) free or subsidized business services that preserves the startups operating/working capital; and 4) improved access to capital markets.[65] While many incubators lack internal seed or venture funds, potential lenders/investors are aware of the advantages of incubated firms.[66] A financial officer with the New Jersey Economic Development Seed and Venture Capital Program stated anecdotally that financial officers at the Authority "view the incubator managers as knowledgeable screeners of loan applicants, and having firsthand knowledge of the client firm . . . lends credibility to the application (for state-sponsored seed or venture capital funds".[67]

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[59] Id.
[60] Id.
[61] Campbell, C., et. al (1988), *Change Agents in the New Economy: Business Incubators and Economic Development*, Minneapolis, MN: Hubert Humphrey Institute of Public Affairs.
[62] Freeman, C., and Perez, C. (1988), *Structural Crisis of Adjustment: Business Cycles and Investment Behavior*, In Technical Change and Economic Theory, ed. L.S. Dosi et. al., New York: Pinter.
[63] Lewis, op. cit., at 5.
[64] Id.
[65] Id.
[66] Id.
[67] Conte, M., (1998), Financial Officer, New Jersey Economic Development Authority, Seminar at the New Jersey Business Incubation Network meeting.

The seven services typically provided by an incubator can be represented as a pyramid. The ones used most often serve as the base. Management is generally encouraged to make efforts to move up the pyramid toward the provision of higher value-added services[68]:

Services on legal, security, IP issues
Seed equity capital, technology sourcing
Skills development, mentoring and counseling
Support on information & international networking
Synergy among clients through exchanges of experiences
Shared office facilities, equipment, pre- & post-incubation
Smart space that is functional, affordable and on flexible terms

As business incubation has proliferated, research has sought to determine its effectiveness as an economic development tool. Campbell et al. (1988) concluded that incubators generated a public sector cost per direct job that ranged from $3,500 to $10,000. DiGiovanna and Lewis (1998) calculated that the average public sector cost per direct job created by six technology incubators in New Jersey was approximately $3,000, significantly less than traditional industrial recruitment programs, which had an average public sector cost per job of over $40,000.[69]

Allen and Barzan (1990) studied the performance of incubated versus similar nonincubated firms in Pennsylvania.[70] The researchers compared 226 client firms across Pennsylvania to a control set numbering 277. The authors conclude that incubator tenants enjoy a superior survival rate and outperform nonincubated firms in terms of growth of employment and sales.

While a formidable preponderance of the literature suggests that incubators generate significant net economic benefits to their communities, another branch of literature explores whether the characteristics of a region can increase the likelihood of successful technology firm incubation. According to Wolfe, et. al. (1999, 2000), regional characteristics for successful incubation include:

1) presence of one or more technology generators. A technology generator is an institution, such as a university, national laboratory, or private research and development laboratory that ensures a sufficient concentration of human capital and engages in an adequate amount of R&D to produce numerous opportunities for new commercialization

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[68] Lalkaka, op. cit., at 4.
[69] DiGiovanna, S., & Lewis, D.A. (1998), *The Future of Technology Incubation in New Jersey: A Strategy for the New Jersey Commission on Science and Technology,* New Brunswick, MJ: Project on Regional and Industrial Economics, Rutgers University, at 6.
[70] Allen, D., & Barzan, E. (1990). *Valued Added Contributions of Pennsylvania's Business Incubators to Tenant Firms and Local Economies*. State College, PA: Appalachian Regional Commission and Pennsylvania Department of Commerce.

ventures.[71] There is no question that Montgomery County, Maryland possesses multiple technology generators, and based on this dimension alone, is an attractive location for technology incubation;
2) a sufficiently skilled labor force that can provide potential clients with employees who have the critical skills to fill the newly created technology-oriented jobs.[72] Again, Montgomery County stands on top of the shoulders of others with its concentration of scientific and technical skill sets;
3) a technology culture in the community. While some may state that Montgomery County lacks the vibrant entrepreneurial culture of Silicon Valley, for instance, there is no question that a culture of innovation and commercialization has taken root in Montgomery County. To the extent that further improvement in the "technology culture" is possible and desirable, this would support the notion of additional incubation, since commercial success among the leading edge of scientific entrepreneurs breeds entrepreneurship among the next generation of innovators; and
4) sufficient investment capital activity in the region, including angel investors, venture capital, traditional financial markets, SBIR grants, state-funded seed and venture funds, and corporate partnership money. It has been said along this dimension that Maryland is a laggard with respect to capital availability[73]. However, this again is support for the notion of incubation, since one of the primary contributions of technology incubators is preservation of early stage company operating capital.

Our interviews also revealed that many firms appreciated the flexibility of incubator space. While private lessors of space may demand leasing of an established minimum square footage, incubator managers generally offer greater flexibility, allowing incubator tenants to gradually ramp up their amount of space leased. This is not only an efficient outcome from an economic point of view, it also serves to preserve the working capital of the early stage firm.

Scholars also note that firms that provide products or services purchased by the government also have relatively greater potential for faster growth. This again supports the notion of heightened technology incubation in Montgomery County, where the federal government is a major purchaser of technology- and non-technology-oriented services and products alike.

Recent events suggest that theory and reality merge in Montgomery County. The theory of technology incubation predicts high demand for incubator space in the County. Reality confirms the theory, at least if one considers the performance of Montgomery County's second public business incubator in Silver Spring. The incubator was 70 percent full one month after opening.[74]

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[71] Wolfe, C., et. al. (1999), *Technology Innovation Centers: A Guide to Principles and Best Practices*, Auburn, CA: Claggett Wolfe Associates.
[72] Id.
[73] The issue is discussed elsewhere in the report.
[74] Shay, K.J., "Montgomery optimistic about incubators", *Gazette*, Aug. 13, 2004.

Competitors to Montgomery County also appear to be actively promoting an incubator-led strategy for economic development. In early 2003, Fairfax County opened its bioscience incubator BioAccelerator. The stated goal of the incubator is to attract young companies in Greater Washington looking for space. In other words, the incubator is intended to attract companies that would otherwise locate to Suburban Maryland/Montgomery County.

Economic Impacts of Additional Incubator Space in Montgomery County

Based on our analysis, we conclude that Montgomery County could generate substantial economic impacts by augmenting its incubator capacity. Based on an extrapolation of the *Maryland Incubator Impact Analysis* prepared by RESI/Towson University in 2001[75], SPG calculated the likely impact of adding 5 properly managed technology incubators in Montgomery County. If one assumes that each of these incubators has been open for at least five years, Montgomery County could anticipate the following per annum future employment and personal income impacts presented in table 11.

Table 12: Predicted Impacts of Five Additional Incubators in Montgomery County

Category of Impact	**Range of Predicted Impacts**
Direct Employment	2,427-2,586 jobs per annum
Total Employment (direct + indirect + induced)	4,485-4,758 jobs per annum
Direct Personal Income[76]	$127.5-$134.6 million per annum
Total Personal Income (direct + indirect + induced)	$205.7-$216.9 million per annum

Direct employment refers to the employment attributable to firms currently occupying incubators and to firms that have graduated from incubators and remained in Montgomery County. Total employment includes these direct jobs as well as their multiplier effect on the local economy.

Our results suggest that by the year 2020, these five incubators would have augmented Montgomery County's job creation capacity by 41.4 percent. Rather than adding a predicted 11,150[77] jobs per annum by the end of the next decade, we believe that Montgomery County could be expected to add approximately 15,770 jobs per annum with a sufficiently aggressive incubator strategy. We pause to note that the jobs directly supplied by incubated firms and graduate firms would pay substantially more than the prevailing County average given their high-tech status. In 2003 dollars, these jobs would pay $67,184 on average. That compares to the prevailing County average annual wage of $48,886.

[75] Please see Appendix G for additional detail on the RESI/Towson University Incubator Study.
[76] Personal Income is measured in 2004 dollars.
[77] This figure is estimated by analyzing average job growth in the County since 1996.

Conclusion

Montgomery County, MD is well positioned to utilize an incubator-driven strategy to help support additional technology clustering within and across technology segments. Certain opportunities facing the County stem from marketplace failures such as the systematic under provision of wet lab space. Provision of such space would provide Montgomery County with competitive advantage vis-à-vis regional and national competitors, and would likely generate substantial net economic benefits for the citizens of the County.

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Bibliography

Adler, N., "Rockville biotech ends hunt for space; stays close to home". *Washington Business Journal*.

Ajzen, I., (1991). *The Theory of Planned Behavior*. Organizational Behavior and Human Decision Processes, 50, 179-211.

Alameda Center for Environmental Technologies. *University Related Incubators* (1997).

Allen, D., & Barzan, E., (1990). *Valued Added Contributions of Pennsylvania's Business Incubators to Tenant Firms and Local Economies*. State College, PA: Appalachian Regional Commission and Pennsylvania Department of Commerce.

Allen, D. & McClusky, R., (1990), *Structure, Policy, and Performance in the Business Incubator Industry*. Entrepreneurship Theory and Practice, Winter, 61-77.

Allen & Stearns, (2002). *Nascent high tech entrepreneurs: The who, where, when, and why*. In G. Libecap (Ed.), *Issues in entrepreneurship: Contracts, characteristics, and country differences*. Greenwich, Connecticut: JAI Press, Inc.

Amick, H., Gendreau, M., & Gordon, C.G., *Facility Vibration Issues for Nanotechnology Research*, Presented at Symposium on Nano Device Technology 2002, May 2-3, 2002, National Chiao-Tung University, Hsinchu, Taiwan.

Amington, C. & Acs, Z., (2000). *The Determinants of Regional Variation in New Firm Formation*. Center for Economic Studies.

Asch, S.E., (1951*), Effects of Group Pressure upon the Modification and Distortion of Judgments*, 177-190 in H. Guetzkow (Ed.), *Groups, Leadership and Men*. Pittsburgh: Carnegie Press.

Atkinson, R. & Gottlieb, P., (2001). *The Metropolitan New Economy Index*. Progressive Policy Institute.

Audretsch, D., (2003). *Entrepreneurship policy and the strategic management of places*. In D. Hart (Ed.), *The emergence of entrepreneurship policy: Governance, start-ups, and growth in the U.S. knowledge economy*. Cambridge, UK: Cambridge University Press.

Audretsch, D. & Feldman, M., (1996). *R&D Spillovers and the Geography of Innovation and Production*. American Economic Review, 86 (3), 630-640.

Begley, T., & Boyd, D., (1987). Psychological characteristics associated with entrepreneurial performance. *Paper presented at Babson Entrepreneurship Research Conference*. Wellesley, Massachusetts: Babson College.

Bhave, Mahesh P., (1993). *Entrepreneurial firm creation processes*. New York: Garland Publishing, Inc.

Botkin, J., & Matthews, J., (1992). *Winning combinations: The coming wave of entrepreneurial partnerships between large and small companies*. New York: John Wiley & Sons, Inc.

Brockhaus, R., & Horowitz, P., (1986). The psychology of the entrepreneur. In D. Sexton, & R. Smilor (Eds.), *The art and science of entrepreneurship*. Cambridge, Massachusetts: Ballinger.

Brown, B., (2003). *The "New Economy": Real or High-Tech Bubble?* Educational Resources Information Center.

Campbell, C., et. al, (1988), *Change Agents in the New Economy: Business Incubators and Economic Development*, Minneapolis, MN: Hubert Humphrey Institute of Public Affairs.

Campbell, C., (1992). *A decision theory model for entrepreneurial acts*. Entrepreneurship Theory and Practice (Fall), 21-27.

Colombo, M., & Delmastro, M., (2002). *How effective are technology incubators? Evidence from Italy*. Research Policy, 31, 1103-1122.

Conte, M., (1998). Financial Officer, New Jersey Economic Development Authority, Seminar at the New Jersey Business Incubation Network meeting.

Contractor, F., & Lorange, P. (Eds.), (2002). *Cooperative strategies in international business: Joint ventures and technology partnerships between firms*. London: Pergamon (Elsevier Science Ltd.).

Cooke, P., Uranga, M.G. & Etxebarria, G., (1997), *Regional innovation systems: Institutional and organizational dimensions*, Research Policy.

Crespi, F., (2004), *Notes on the Determinants of Innovation: A Multi-Perspective Analysis*, The Fondazione Eni Menrico Mattei Note di Lavoro Series Index.

Davis, B., (1986). *Role of venture capital in the economic renaissance of an area*. In R. Hirsch (Ed.), *Entrepreneurship, intrapreneurship, and venture capital: The foundation of economic renaissance*. Lexington, Massachusetts: Lexington Books, D.C. Heath and Company.

Deeds, D., DeCarolis, D., & Coombs, J., (1999). *Dynamic capabilities and new product development in high technology ventures: An empirical analysis of new biotechnology firms*. Journal of Business Venturing, 15, 211-229.

DiGiovanna, S., & Lewis, D.A., (1998), *The Future of Technology Incubation in New Jersey: A Strategy for the New Jersey Commission on Science and Technology*, New Brunswick, MJ Project on Regional and Industrial Economics, Rutgers University.

Douglas, E., & Shepherd, D., (1999). *Entrepreneurship as a utility maximizing response*. Journal of Business Venturing, 15, 231-251.

Duobinis, S., (2001). *Technology, metropolitan growth, and housing markets*. Housing Economics, 49(7), 6-10.

Ernst & Young. *Venture Capital Climate for Bioscience in Maryland*, December, 2001.

Florida, R., (2003). *Entrepreneurship, creativity, and regional economic growth*. In D. Hart (Ed.), *The emergence of entrepreneurship policy: Governance, start-ups, and growth in the U.S. knowledge economy*. Cambridge, United Kingdom: Cambridge University Press.

Freedman & Von Bargen, J., (2003). *Entrepreneurship as a state and local economic development strategy*. In D. Hart (Ed.), *The emergence of entrepreneurship policy: Governance, start-ups, and growth in the U.S. knowledge economy*. Cambridge, UK: Cambridge University Press.

Freeman, C., & Perez, C., (1988). *Structural Crisis of Adjustment: Business Cycles and Investment Behavior*, In L.S. Dosi et. al (Ed.), *Technical Change and Economic Theory*. New York: Pinter.

Furman, J.L., Porter, M.E. & Stern, S., (2002). *The Determinants of National Innovative Capacity*, Research Policy, 31 (6).

Goldfisher, A., "Incubators Hatch Business Chicks", *The Business Journal*, August 5-11, 1996.

Gompers, P., Lerner, J., & Scharfstein, D., (2003). *Entrepreneurial spawning: Public corporations and the genesis of new ventures*, 1986-1999. NBER Working Paper 9816. Cambridge, Massachusetts: National Bureau of Economic Research.

Harper, D., (1996). *Entrepreneurship and the market process*. London: Routledge.

Hedgpeth, D., "At a Loss for Laboratory Space", *Washington Post*, March 6, 2000.

Hisrich, R., (1986). *The woman entrepreneur: Characteristics, skills, problems, and prescriptions for success*. In D. Sexton, & R. Smilor (Eds.), *The art and science of entrepreneurship*. Cambridge, Massachusetts: Ballinger.

Holmes, T., & Schmitz, J., (1990). *A theory of entrepreneurship and its application to the study of business transfers*. Journal of Political Economy, 98(2), 265-294.

Jacobs, J., (1969). *The Economy of Cities*. Penguin, London.

Kaplan, S., & Stromberg, P., (2003). *Financial contracting theory meets the real world: An empirical analysis of venture capital contracts*. Review of Economic Studies, 70, 281-315.

Klein, S. & Rosenberg, N., (1986). *An overview of innovation*, in R. Landau, and N. Rosenberg, (Eds.), *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington, National Academy Press.

Kozmetsky, G., (1985). *Technology venturing: The new American response to the changing environment*, in E. Konecci, & R. Kuhn (Eds.), *Technology venturing*. New York: Praeger Publishers.

Lalkaka, R., (2003). *Technology business incubation: Role, performance, linkages, trends*. Paper for the National Workshop on Technology Parks and Business Incubators. Isfahan, Iran.

Lehrer, M., & Asakawa, K., (2004). *Pushing scientists into the marketplace: Promoting science entrepreneurship*. California Management Review, 46(3), 55-76.

Lewis, D., (2001). *Does technology incubation work? A critical review*. Reviews of Economic Development Literature and Practice, 11. Report prepared by Rutgers University for U.S. Department of Commerce, Economic Development Administration.

Lichtenstein, G., (1992), *The Significance of Relationships in Entrepreneurship: A Case Study of the Ecology of Enterprise in Two Business Incubators*, Doctoral diss., University of Pennsylvania, Philadelphia.

Listokin (Eds.), *New tools for economic development: The enterprise zone, development bank, and RFC*. Piscataway, NJ: Rutgers University, Center for Urban Policy Research.

Meadows, G., & Mitrisin, J., (1981). *A national development bank: Survey and discussion of literature on capital shortages and employment changes in distressed areas*.

Marshall, A., (1920), *Principles of Economics*, Macmillan, London.

Nash-Hoff, M., (1998). *For Profit Incubators*, Athens, OH: NBIA.

NBIA Resource Center. *Principles and Best Practices of Successful Business Incubation*, (1996).

Porter, M., (1998). *Clusters and the New Economics of Competition*. Harvard Business Review, 76 (6), 77-90.

Poutsma, E., (1996). *Scientists as Entrepreneurs: The Importance of Entrepreneurial Districts*. Nijmegen Business School.

RESI, (2001). *Maryland incubator impact analysis*. In collaboration with Maryland Business Incubation Association. Funded by Maryland Technology Development Corporation (TEDCO).

Rice, M., (1992), *Invention Mechanisms used to Influence the Critical Success Factors of New Ventures: An Exploratory Study*. Doctoral diss., Renssalaer Polytechnic Institute, Troy, NY.

Robinson, S., "N.M. Incubators Fail to Thrive," *Albuquerque Tribune Online*.

Romanelli, E., & Schoonhaven, C., (2001). *The local origins of new firms*. In C. Schoonhaven, & E. Romanelli (Eds.), *The entrepreneurship dynamic: Origins of entrepreneurship and the evolution of industries*. San Francisco: Stanford University Press.

Saxenian, A., (1994). *Regional advantage: Culture and competition in Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press.

Schachtel, M., Bi, Y., & Kuklick, M., (2004). *The genealogy of Maryland information technology company founders: bioinformatics, medical informatics, health informatics*. Prepared for Maryland Department of Business and Economic Development and Maryland Technology Development Corporation.

Schumpeter, J., (1939), *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process,* McGraw-Hill, New York and London

Schumpeter, J., (1934). *The theory of economic development*. Cambridge, Massachusetts: Harvard University Press.

Shahidi, H., (1998), *The Impact of Business Incubators on Entrepreneurial Networking: A Comparative Study of Small, High-Technology Firms*. George Mason University.

Shay, K. J., "Montgomery optimistic about incubators", *Gazette*, Aug. 13, 2004.

Smilor, R., (1986). *Building indigenous companies: The technology venturing approach*. In R. Hirsch (Ed.), *Entrepreneurship, intrapreneurship, and venture capital: The foundation of economic renaissance*. Lexington, Massachusetts: Lexington Books, D.C. Heath and Company.

Smilor, R., (1996), *Why Incubator Might Fail*, In A Comprehensive Guide to Business Incubation, ed. Sally Hayhow, Athens, OH: NBIA.

Smilor, R., & Sexton, D., (1996). *Leadership and entrepreneurship: Personal and organizational development in entrepreneurial ventures*. Westport, Connecticut: Quorum Books.

Stuart, T.E. & Ding, W.W., (2004), *When Do Scientists become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences*.

Suchman, M., Steward, D., & Westfall, C., (2001). *The legal environment of entrepreneurship*. In C. Schoonhaven, & E. Romanelli (Eds.), *The entrepreneurship dynamic: Origins of entrepreneurship and the evolution of industries*. Berkeley, California: Stanford University Press.

Tang, L., & Koveos, P., (2004). *Venture entrepreneurship, innovation entrepreneurship, and economic growth*. Journal of Developmental Entrepreneurship, 9(2), 161-171.

Tornatzky, et. al., (1996). *The Art and Craft of Technology Business Incubation: Best Practices and Tools from 50 Programs*. Research Triangle, NC: Southern Technology Council.

Van Bergen, J., (2004). *The stages of industry growth*. Investopia.com, March 5, 2004.

Von Hipple, E., (1994), *Sticky Information and the Locus of Problem Solving: Implications for Innovation, Management Science*. Management Science, 40 (4), 429-439.

Wolfe, C., et. al., (1999). *Technology Innovation Centers: A Guide to Principles and Best Practices*, Auburn, CA: Claggett Wolfe Associates.

Wolfe, C., Adkins, D. & Sherman, H. *Best Practices in Business Incubation* (2000).

Appendix A: High-Technology Industry Codes

SIC Codes (before 2001)

SIC Code	Industry Description
131	Oil and Gas Extraction
281	Industrial Inorganic Chemicals
282	Plastic Materials and Synthetics
283	Drugs
286	Industrial Organic Chemicals
289	Misc. Chemical Products
291	Petroleum Refining
348	Ordnance and Accessories, Not Elsewhere
351	Engines and Turbines
353	Construction and Related Machinery
356	General Industrial Machinery
357	Computer and Office Equipment
361	Electric Distribution Equipment
362	Electrical Industrial Apparatus
363	Household Appliances
364	Electrical Lighting and Wiring Equipment
365	Household Audio and Video Equipment
366	Communications Equipment
367	Electronic Components and Accessories
369	Misc. Electric Equipment and Supplies
372	Aircraft and Parts
376	Guided Missiles, Space Vehicles, Parts
381	Search and Navigation Equipment
382	Measuring and Controlling Devices
384	Medical Instruments and Supplies
385	Ophthalmic Goods
386	Photo Equipment and Supplies
489	Communication Services, Not Elsewhere Classified
737	Computer and Data Processing Services
871	Engineering and Arch. Services
873	Research and Testing Services

NAICS Code (after 2000)

NAICS Code	Industry Description
2111	Oil/Gas Extraction
3251	Basic Chemical Manufacturing
3254	Pharm/Medicine Manufacturing
3332	Industrial Machinery Manufacturing
3333	Commercial/Service Industry Machinery Manufacturing
3341	Computer and Peripheral Equipment Manufacturing
3342	Communications Equipment Manufacturing
3343	Audio/Video Equipment Manufacturing
3344	Semiconductor/Other Electronic Component Manufacturing
3345	Navigational/Measuring/Electromedical/Control Instrument Manufacturing
3364	Aerospace Product and Parts Manufacturing
4234	Prof. and Commercial Equipment and Supplies Merchant Wholesalers
5112	Software Publishing
5161	Internet Publishing/Broadcasting
5179	Other Telecommunications
5181	Internet Service Providers and Web Search Portals
5182	Data Processing, Hosting and Related
5413	Arch./Engineering and Related
5415	Computer Systems Design and Related
5416	Management, Scientific and Tech Consulting
5417	Scientific Research and Development Services

Appendix B: Geography and Innovation

Over time, social scientists have become aware of the regional characteristics of technological change. In a recent contribution by J. Furman, M. Porter and S. Stern (2002), the authors introduced the concept of *national innovation capacity*, which is "the ability of a country to produce and commercialize a flow of innovative technology over the long term".[80]

This regionally oriented research has emphasized (among many other items) the role played by institutions and public actors in determining the national innovative capacity.[81] In this literature, institutions are generally viewed as working to reduce uncertainty and to sustain and catalyze the accumulation and diffusion of knowledge.[82] Notably, differences in institutional and policy choices regarding universities, capital availability, patent systems, public research laboratories and R&D subsidies are perceived as central factors shaping the rate of innovation.[83]

The breakthrough work in this body of literature came as early as 1920, when Marshall claimed that geographical agglomeration of industries produced knowledge externalities that can have positive effects on the rate of innovation and economic growth.[84] Arrow (1962) and others offer further insight on the particular characteristics of the knowledge good and the notion that knowledge "spills over".[85] Understanding the nature of spillover is central for regional economic development, because most scholarship recognizes that because a great part of knowledge is tacit and localized, spillover effects are spatially bound.[86] It is for this reason that Von Hipple (1994) argues that face-to-face and repeated interactions remain the most effective way to transmit knowledge producing positive externalities.[87] Hence, physical proximity enhances flows of technological knowledge spreading across entrepreneurs, engineers, workers, etc.[88]

The view expressed by the so-called Marshall-Arrow-Romer (MAR) model is that knowledge spillovers are enhanced by the presence of single industry concentration(s) in a given region.[89] Communications and knowledge transmission are less expensive in the context of concentrated industry, creating a clear policy implication: governments should stimulate local concentration in key industries when it appears that there is a rationale for

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[80] Furman, J.L., Porter, M.E. & Stern, S. (2002), *The Determinants of National Innovative Capacity*, Research Policy, 31 (6), 899-933.
[81] Crespi, op. cit., at 3.
[82] Id.
[83] Id.
[84] Marshall, A. (1920), *Principles of Economics*, Macmillan, London. Marshall's insights were restated and refined by Arrow (1962) and Romer (1986, 1990).
[85] Crespi, op. cit., at 12.
[86] Id.
[87] Von Hipple, E. (1994), *Sticky Information and the Locus of Problem Solving: Implications for Innovation, Management Science*, at 429.
[88] Crespi, op. cit., at 13.
[89] Id.

the industry to cluster in the community.[90] Porter (1998) also highlights the notion that talented people (i.e., the creative class) with different backgrounds can easily be attracted to a region because clustering reduces the risk of relocation for employees.[91]

Jacobs (1969) adds a critical dimension to the issue of industry clustering. She believes that a major source of knowledge spillovers originates with the interaction of actors belonging to different industries.[92] This is a key insight and one that is central to this study. According to Jacobs, industry diversity within a given region is the key driver of technological externalities and innovation. The diversity of skills, expertise, experiences, needs and the convenience of human relationships offered in a local context are viewed as major sources of innovation and growth promotion.[93]

The public policy implication is that where possible, communities should seek to develop multiple clusters under the theory that these clusters can and will promote one another. Empirically, Jacobs appears to be on solid footing. It is the case that most technologically advanced regions (e.g., Silicon Valley, Boston and Greater Washington) have a presence in multiple cutting edge segments, consistent with the Jacobsian view and prediction.

Accordingly, the importance of a local institutional framework for innovation has been stressed by the National Innovation System approach through the idea of a Regional Innovation System (RIS).[94] An RIS is defined as a local system in which firms and other types of institutions are involved in systematic interactive learning activities targeted at producing and developing innovations.[95] According to this perspective, local public intervention that helps to appropriately structure knowledge infrastructures promotes technology production and diffusion by stimulating flows of knowledge and technology spillovers.[96]

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[90] Porter (1998, p. 78) defines clusters as a "geographic concentration of interconnected companies and institutions in a particular field". According to Porter, clusters affect competition by increasing the productivity of companies cited in a certain area, by accelerating the rate of technological change, and by encouraging the entry of new firms in the market. The desirability of new firm formation and market entry promoting and sustaining clusters is one of the key rationales behind the use of publicly funded incubators.

[91] Crespi, op. cit., at 14.

[92] Jacobs, J., (1969), *The Economy of Cities*, Penguin, London.

[93] Id.

[94] Cooke, P., Uranga, M.G. & Etxebarria, G. (1997), *Regional innovation systems: Institutional and organizational dimensions*, Research Policy, 26, 475-491.

[95] Crespi, op. cit., at 14.

[96] Id.

Appendix C: Stages of Innovation

It is now widely accepted among economists and policymakers that it is the capacity for innovation and the ability to deploy new technologies that determines the rate of growth and ultimately the level of prosperity of a regional economic system (Solow, 1956; Romer, 1990; Aghion and Howitt, 1992; and Metcalfe, 2003).[97] According to Joseph Schumpeter, technological change consists of the introduction of new products (product innovation), production processes (process innovation) and management methods (organizational innovation).[98] This formulation of what constitutes technological change/innovation will be the formulation utilized throughout this study.

The broadly used Schumpeterian trilogy segments technological change by its three phases: Invention, Innovation and Diffusion.[99] Schumpeter probably conceived the process as a linear one, in which invention generated new scientific and technological ideas. This in turn led to the introduction of novelties in the economic system (innovation), followed finally by the distribution over time and space of the adoption of innovations (diffusion).[100]

Contemporary scholars understand that the process of technological change is non-linear. The chain model proposed by Klein and Rosenberg (1986) accounts for and assumes the presence of substantial interrelations between the various stages of technological change by considering information feedbacks along the chain.[101] In this way, the joint contribution of science and the marketplace to the innovation process is recognized and highlighted. This serves as a key insight for this study, since policymakers must be simultaneously aware of their potential capacity to affect innovation either by serving the scientist directly or by appropriately stimulating constructive marketplace adjustments, including through the direct supply of short supplied research/office space.

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[97] Crespi, F. (2004), *Notes on the Determinants of Innovation: A Multi-Perspective Analysis*, The Fondazione Eni Menrico Mattei Note di Lavoro Series Index, at 1.
[98] Schumpeter, J. (1939), *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, McGraw-Hill, New York and London.
[99] Crespi, op. cit., at 1.
[100] Id.
[101] Klein, S. & N. Rosenberg (1986), *An overview of innovation*, in R. Landau, and N. Rosenberg, (eds.), *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington, National Academy Press.

Appendix D: Entrepreneurship

Choosing Entrepreneurship: Maximizing Individual Utility

One of the most interesting of all questions addressed by researchers on entrepreneurial behavior is that of why one individual will choose an entrepreneurial path while another does not. The earliest research on the origins of entrepreneurship focused on what entrepreneurs do and how they do it. In the 1930s, research focused specifically on the notion of innovation and how the entrepreneur deploys innovations to either create new firms, connect various markets, or to expand or modify existing markets.[102] More recently, research found that entrepreneurs distinguish themselves by exploiting technical progress and emerging capabilities to develop new and marketable products and services (Holmes & Schmitz, 1990).

Research that has focused on the question of why individuals choose to become entrepreneurs has produced interesting findings, but not a comprehensive theory with sufficient explanatory power. Economists and other social scientists have approached the question from different perspectives, with economists tending to utilize economic concepts such as expected net present value of profit and expected utility gained (Campbell, 1992; Eisenhauer, 1995), and other social scientists tending to focus on personality traits, attitudinal dimensions, intentions, and demographic characteristics (Brockhaus & Horowitz, 1986; Hisrich, 1986; Begley & Boyd, 1987; Ajzen, 1991).

In 1999, an economic model of entrepreneurial intentions was developed for the first time that lends substantial explanatory insight into the issue of why individuals choose to become—or not become—entrepreneurs. Douglas & Shepherd utilize a model that explains an individual's choice between employment and self-employment as a function of the utility of five crucial factors: 1) the income the individual expects to gain, as well as utility or disutility from various working conditions, including 2) work effort, 3) risk bearing, 4) independence, and 5) other working conditions, such as social interaction or use of facilities or other perquisites. Individuals will exhibit either preference or aversion towards each, and it is the degree of that preference or aversion that determines the total utility an individual derives from each occupational choice. In other words, it is the sum of the utility and disutility from these sources that determines the career decision. Douglas & Shepherd therefore see the choice for entrepreneurship as a utility maximizing response (Douglas & Shepherd, 1999).

Douglas & Shepherd find that all individuals have an incentive for self-employment (assuming availability of resources and capital), and that the greater their managerial and entrepreneurial ability, tolerance for risk bearing, and preference for independence or decision-making control, the greater will be their incentive to be self-employed (Douglas & Shepherd, 1999). Douglas & Shepherd highlight some interesting implications of their groundbreaking model:

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[102] Schumpeter, J., (1934). *The Theory of Economic Development*. Cambridge, Massachusetts: Harvard University Press.

- Although high tolerance of work effort, high tolerance for risk, and a strong preference for independence each works in favor of entrepreneurship, none of these attitudes are either necessary or sufficient conditions for entrepreneurship.

- It is conceivable that an individual who is highly averse to work, risk, and independence could nevertheless earn enough income in a self-employment situation to more than offset the disutility of effort, risk, and independence exacted from him in that employment situation.

- The right opportunity has to be available, *as well as the necessary funding*, before an individual can actualize his intentions to become an entrepreneur, hence it is likely that individuals will work for someone else until they gain more experience and/or funding, and or find the right opportunity.

- Entrepreneurial abilities and attitudes are desirable in all managers/workers. To retain employees, firms must recognize and compensate entrepreneurialism and, in order to retain such employees, consider utilizing incentives that share risk and reward.

- Business and management educators should emphasize the development of entrepreneurial abilities and attitudes since such tendencies are good for businesses of all types (Douglas & Shepherd, 1999).

Douglas & Shepherd conclude then that it is not the presence or absence of any one attitude that determines entrepreneurial behavior, but rather the combination and relative weights of multiple factors. They further conclude that research should next focus on developing that capacity to predict entrepreneurship by designing and testing instruments that measure the degree of preference or aversion for income, work, risk, and independence (Douglas & Shepherd, 1999).

Stimulus for Entrepreneurial Opportunity Recognition

Following in-depth personal interviews with entrepreneurs, Bhave (1993) found that while new venture creation is driven by highly diverse circumstances across individuals, there are two quite distinct paths in the process followed by these entrepreneurs in recognizing opportunity: externally stimulated opportunity recognition and internally stimulated opportunity recognition.

Under his notion of externally stimulated opportunity recognition, Bhave suggests that the decision to start a new business venture precedes recognition of opportunity for some entrepreneurs. Some entrepreneurs he interviewed decided to pursue new ventures in response to specific changes in circumstances, such as when an employer decided to relocate and they chose not to (Bhave, 1993).

Bhave also suggests that entrepreneurs who decided to begin new ventures before seizing a specific venturing opportunity recognized vastly more opportunities than they seriously selected for pursuit. Most of these entrepreneurs reported that they had to avoid becoming distracted and unfocused by the multiple opportunities within their grasp.

Thus, the decision to pursue a new venture was followed by a process whereby entrepreneurs initiated a strategy to align their knowledge, skills, and abilities with needs of the existing marketplace, reducing the pool of opportunities to a narrower, more realistic set for consideration. Bhave refers to these processes prior to selection of a venture to pursue as opportunity recognition, opportunity filtration, and opportunity refinement. Of the entrepreneurs in the sample, 59 percent followed this pattern of externally stimulated opportunity recognition (Bhave, 1993).

Conversely, other entrepreneurs interviewed by Bhave followed the opposite path: recognition of an opportunity suitable for pursuit preceded the entrepreneur's decision to start a new venture. For those on the path of internally stimulated opportunity recognition, entrepreneurs managed to identify or were exposed to potentially marketable products and services that were not being satisfied in any meaningfully sufficient manner by existing methods and markets. As entrepreneurs realized that new ventures could be created to satisfy these unmet needs, they considered and refined the range of opportunities and defined appropriate business concepts to address and confront the problem (Bhave, 1993).

Bhave cites an example of an electronic medical instrument to illustrate this path to market. Following a conversation with a doctor during which a need was discussed for certain kinds of medical measurements, an entrepreneur pursued the need through laboratory research and development, which later resulted in a prototype instrument. Thus, identification of the need for a marketable product or service precipitated a series of responses that included recognition of the business opportunity, development of a business concept, and commitment by the entrepreneur, culminating in product to market. Bhave indicates that 41 percent of the entrepreneurs in the sample followed the path of internally stimulated opportunity recognition (Bhave, 1993).

Creation of Venture Capital Backed Start-Ups

The National Bureau of Economic Research (NBER) contributes some of the most profound and interesting insights into the factors that contribute to the creation of venture capital backed start-ups, a process referred to as "entrepreneurial spawning." In a recent analysis of firms that successfully obtained venture capital financing, NBER is effectively able to contrast two competing views of the spawning process.

According to one view, which NBER suggests is exemplified by the history of Fairchild Semiconductors, employees of established firms are trained and conditioned to be entrepreneurs through exposure to the entrepreneurial process and by working in a network of entrepreneurs and venture capitalists. Individuals employed by emerging entrepreneurial firms, burdened by the forces of uncertainty and under the threat of potential failure and dissolution, simply may be conditioned with a lower aversion to risk. NBER, citing findings from earlier research, suggests a number of reasonable arguments: 1) potential entrepreneurs gain exposure to both suppliers and potential customers, 2) potential entrepreneurs obtain on-the-job training on establishing new ventures from experienced entrepreneurs, and 3) there is a self-selection dynamic at work whereby the less risk averse are likely to become involved with risky, entrepreneurial ventures (Gompers, Lerner, & Scharfstein, 2003).

According to a second view, which NBER suggests is exemplified by the Xerox Corporation, individuals become entrepreneurs because the large bureaucratic companies for which they work will not or cannot fund their entrepreneurial ideas. Citing earlier research, NBER suggests a number of reasonable arguments: 1) large, established firms may be organizationally incapable of capitalizing on “disruptive technologies,” 2) senior managers of established firms may be incapable of considering opportunities outside the core lines of business for which they are responsible, and 3) rather than considering these liabilities, large established firms are solely concentrated on their principal lines of business, for the health, growth, efficiency, and survivability of the firm (Gompers, Lerner, & Scharfstein, 2003).

NBER extracted a dataset from VentureOne, established in 1987, which collects data on firms that have obtained venture capital financing. NBER examined the founders and initial executive officers that joined firms listed in the VentureOne database during the period 1986-1999. On the basis of the VentureOne analysis, NBER presents findings in five distinct areas, including: 1) determinants of spawning, 2) characteristics of firms that spawn, 3) intensity of spawning, 4) determinants of annual spawning levels, and 5) relatedness of start-up to parent. The following summarize the critical findings of the NBER analysis in these areas:

- Public companies that were once venture capital backed are more likely to spawn new ventures than companies that were not venture capital backed (spawning 26.4 percent more firms than public companies that were not venture capital backed).

- Younger firms that were backed by venture capitalists at an earlier point and that are located in the main hubs of venture capital activity (Silicon Valley and Massachusetts) are more likely to spawn new firms than older firms located outside of these hubs.

- Having research activities outside of the main venture capital related areas, which NBER considers a degree of focus, reduces the level of spawning; in other words, diversification suppresses the likelihood of spawning (Gompers, Lerner, & Scharfstein, 2003).

NBER suggests several implications from its analysis of venture-backed companies:

> “In particular, they suggest that entrepreneurial activity in a given region has increasing returns. Stimulating entrepreneurship in a region with few

> existing entrepreneurial firms is difficult; there may be many individuals with the technological know-how to start a new venture capital backed firm, but many fewer who know how to start new companies. In addition, the network of suppliers and customers may not be strong enough to support a new venture. Policies that have sought to foster entrepreneurial and venture capital activity by providing capital or investment incentives may not be enough. Instead, regions may need to attract firms with existing pools of workers who have the training and conditioning to become entrepreneurs" (Gompers, Lerner, & Scharfstein, 2003)."

<u>The Role of Government Policy in Stimulating Technology Formation and Diffusion</u>

Smilor (1986), drawing on earlier work (Kozmetsky, 1985), suggests that there are eight interactive stimulants that are currently driving technology venturing in the U.S. These include: relationships between universities and corporations; programs and linkages between government, business, and universities; private joint efforts for scientific advances; blossoming venture capital industry; institutional arrangements between the public, private, and nonprofit sectors; local community initiatives for economic growth and development; leading-edge state government growth initiatives fostering high technology, and creative federal government programs (Smilor, 1986).

Smilor describes the American business landscape as one of "hypercompetition," occurring between countries, across states, and within communities. The challenge for today's communities, Smilor argues, is not the struggle over attracting existing companies to relocate, but rather successfully building indigenous companies. The process of building indigenous companies involves harnessing local entrepreneurial talent, building companies that produce local jobs, keeping home-grown talent in place within the community, and encouraging economic diversification and technological innovations through a system of rewards that institutionalizes the dynamics (Smilor, 1986).

Smilor argues that communities must position themselves in a manner that increases their attractiveness as bases for technology venturing, by emphasizing what he calls "quality for life." Communities must recognize the economic importance of its infrastructure, including the quality of schools, parks, and playgrounds, outdoor recreation activities, cultural events, community ambience, safety, and cleanliness, ease of transportation within the city and air accessibility, housing costs, climate and air quality, employment opportunities for family, and quality of the community in terms of raising children and general living conditions (Smilor, 1986).

Smilor concludes that economic development is not due to random occurrences, but rather reflects the ability of a community to react proactively to the needs of new technology ventures. Components of an overall competitive community strategy include:

- investment in a viable public-private infrastructure, including roads and critical services, but also creating diverse educational and cultural opportunities;

- a banking community sensitive to the unique problems and needs of new technology ventures, as well as an aggressive venture capital sector;

- presence of a skilled pool of professionals with a local, indigenous capacity to supply adjunct and support services, rather than relying on a distant supply (Smilor, 1986).

Appendix E: Best Practices in Business/Technology Incubation

As with all public initiatives, the quality of implementation determines the success of the endeavor. Technology incubators now possess a long enough history to provide researchers with insight into best practices. This section of the report is designed to provide information on best practices. Virtually without exception, these best practices are relevant in a Montgomery County, MD context.

Allen and McClusky (1990) demonstrate that to achieve new firm formation, graduation, and job creation by business incubator clients requires patience from government sponsors.[103] Rice (1992) determined that incubator managers' counseling of client firms contributed to the success of firms, but that managers often failed to spend enough time with clients because of inappropriate organization and financial constraints.[104]

Lichtenstein (1992) provides empirical evidence that the networking and relationships provided by an incubator lead to improved client firm performance in terms of increased sales, lower cost, enhanced capabilities and reduced risk.[105] The benefit most frequently asserted by entrepreneurs was moral and psychological support derived from being part of an incubator. They also mentioned the benefit of skills acquisition and new ideas generation derived through opportunities to observe and ask questions of other entrepreneurs and incubator staff.[106]

Research by Shahidi (1998) tested the hypothesis that there are more networking opportunities for technology incubator client firms than for similar nonincubated firms and that these networks contribute to the performance of technology incubator client firms.[107] Shahidi concluded that these networks had demonstrable positive impacts on client firms.[108] The opportunity to access customer networks offered incubated firms more informal sales contacts. Further, the range of consultants and advisors associated with incubators provided client firms with an advantage.[109] These benefits led to statistically higher rates of equity capital, grants, and seed fund financing for incubated firms than for similar nonincubated firms.[110]

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[103] Allen, D. & McClusky, R., (1990), *Structure, Policy, and Performance in the Business Incubator Industry*. Entrepreneurship Theory and Practice, Winter, 61-77.
[104] Rice, M., (1992), *Invention Mechanisms used to Influence the Critical Success Factors of New Ventures: An Exploratory Study*, Doctoral diss., Renssalaer Polytechnic Institute, Troy, NY.
[105] Lichtenstein, G., (1992), *The Significance of Relationships in Entrepreneurship: A Case Study of the Ecology of Enterprise in Two Business Incubators*, Doctoral diss., University of Pennsylvania, Philadelphia.
[106] Id.
[107] Shahidi, H., (1998), *The Impact of Business Incubators on Entrepreneurial Networking: A Comparative Study of Small, High-Technology Firms*. George Mason University.
[108] Id. Shahidi surveyed 383 nonincubated, small, high-tech firms less than eight years old and 284 technology incubator clients. The response rate was 23 percent and 25 percent, respectively. He did not control for region.
[109] Id.
[110] Id.

Tornatzky et a. (1996) endeavored to develop a set of best practices for technology incubation and surveyed fifty technology incubators that were perceived by peers as leading edge or best in class.[111] The analysis suggests that in the case of university-hosted incubators, the services designed to assist firms with research and technology development were more readily available and finance and capitalization services were provided at a slighter higher rate than nonuniversity technology incubators.[112]

A report prepared on behalf of the Maryland Technology Development Corporation describes ten best practices that emerge from a study of eight leading international incubators, including one in Israel, one in England, four in California, and one each in New York and Colorado.[113] These ten business incubation best practices are:

1) comprehensive business assistance program, which includes among other items needs identification, coaching and facilitation, and client progress monitoring;
2) professional infrastructure, which includes a know-how or professional services network, mentors and advisory boards;
3) client capitalization and financing, which includes equity capital, debt capital, capital networks and brokers, in-house capital funds and corporate partners;
4) client networking, which includes the use of brown bag lunches, CEO forums and affiliates programs;
5) technology transfer and commercialization;
6) university and federal laboratory linkages, which include consulting from faculty and technologists, support from student interns, access to technical facilities and equipment, and access to databases and researchers;
7) facility basics, which includes providing maximum space flexibility and encouraging client interaction through the use of common meeting areas;
8) governance and staffing, which includes a nonprofit tax structure and the presence of private sector perspectives on the governing body;
9) descriptive and agreed upon client screening and graduation procedures; and
10) routine incubator evaluation, which includes setting up basic guidelines for the measurement of incubator performance.

Though most of these best practices are reflections of common sense and recent experience, best practice number eight deserves some special consideration. The question is whether government sponsorship and corresponding non-profit status are required, or whether a private-led model of for-profit incubators makes sense. Attendees of the 2000 Annual NBIA Conference in Cleveland included many associated with for-profit incubators.[114] Nash-Hoff (1998) interviews with fifty for-profit incubators revealed that nearly one in five had closed or was in the process of closing, this before the tech downturn to follow two years later.[115]

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[111] Tornatzky, et. al., (1996), *The Art and Craft of Technology Business Incubation: Best Practices and Tools from 50 Programs,* Research Triangle, NC: Southern Technology Council.
[112] Id.
[113] Wolfe, C., Adkins, D. & Sherman, H. (2000), *Best Practices in Business Incubation*.
[114] Lewis, op. cit., at 19.
[115] Nash-Hoff, M., (1998). *For Profit Incubators,* Athens, OH: NBIA.

Today, it is unclear whether the for-profit model can be broadly resurrected. The for-profit model does not offer the patient capital and mentoring of the government-sponsored model, and therefore falls outside the realm of basic best practice.

This is not meant to suggest that policymakers and others should not take away lessons from closures. Smilor (1996) suggests five potential reasons why an incubator program may fail to deliver expected results.[116] The reasons are: 1) inflated expectations; 2) selection of the wrong manager; 3) overestimation of the incubator's role in an economic development plan; 4) overspending; and 5) a failure to leverage resources.[117]

Others have found that site selection is extremely important, and that incubator locations must be sensitive to rush hour traffic patters. Also, government must not only provide resources for facilities, but also for operations since cutting back staffing and limiting the manager to part-time status, for instance, defeats the purpose of incubation.[118] This last point is important in a Maryland context. While the State of Maryland has funded the physical infrastructure of some of its incubators, it has no ongoing program of operating support.[119]

Our interviews also revealed that like any business entity, incubators need to properly "brand" themselves. Our interviewees pointed to the Chesapeake Innovation Center in Anne Arundel County and the Shady Grove Life Sciences Center in Rockville as two incubators that had successfully branded themselves, and thereby established powerful market niches. In the case of the Chesapeake Innovation Center, branding was accomplished in less than a year.

[116] Smilor, R., (1996). *Why Incubator Might Fail*, In A Comprehensive Guide to Business Incubation, ed. Sally Hayhow, Athens, OH: NBIA.
[117] Id.
[118] Lewis, op. cit., at 22.
[119] Wolfe, et. al., op. cit., at 3.

Appendix F: Lessons Learned from Silicon Valley and Boston's Route 128

This appendix is offered merely to provide interesting background on some of the social and institutional aspects of technology community formation, with an eye toward possibly providing insight to stakeholders in Montgomery's County's technological future.

In a recent comparative analysis, Saxenian utilizes the historical development of Silicon Valley and that of Boston's Route 128 to illustrate critical issues in understanding the effectiveness and strength of regional economies not as "clusters of factors of production," but rather as integrated industrial systems. Fundamental differences between the two economies, Saxenian emphasizes, helps underscore the critical relationship between regional networks and the process of adaptability and survivability (Saxenian, 1994). Saxenian suggests that: "Far from being isolated from what lies outside them, firms are embedded in a social and institutional setting that shapes, and is shaped by, their strategies and structure." The following section describes systemic and process differences between the Silicon Valley experience and the experience of Boston's Route 128, and how such differences contributed to fundamentally different outcomes.

<u>California's Silicon Valley</u>

Though Silicon Valley and Boston's Route 128 have been hailed as examples of regional economic development with common energies and dynamics, Saxenian explains that fundamental differences were exposed between the two regions as each faced crises in the early 1980s and were forced to adapt to rapid change. Saxenian paints a fascinating historical portrait of the Silicon Valley experience, in contrast to Boston's Route 128, as one of intensive competition and community. As the region began to grow south from Palo Alto, California, the emerging entrepreneurs developed a unique identity of themselves as technological pioneers, eschewing the traditions and patterns of production that were the roots of the east coast establishment, creating a technical culture that "transcended firm and function," and in the process developing "firms that were organized as loosely linked confederations of engineering teams" (Saxenian, 1994).

Saxenian keys specifically on the establishment of Fairchild Semiconductor Corporation, for which so many of the region's early engineers had once been employed beginning in the 1960s, as the foundation for experimentation with new forms of institutions, organizations, and methods of production. Many firms in the region display the Fairchild "family tree," illustrating the multitude of spin-off firms that "glorifies the entrepreneurial risk-taking and competitive individualism that distinguish the region's business culture." In addition, the common heritage among many new entrepreneurs contributed to quasi-familial relationships, formal collaboration and information sharing about competitors, customers, and markets, as well as extensive informal socializing (Saxenian, 1994). The end result was a cohesive and tight-knit technical community that was also marked by intense competition for labor and extensive job mobility across firms (Saxenian, 1994).

However, as Saxenian argues, Silicon Valley's engineers maintained friendships and loyalties to individuals, developing a "stronger commitment to one another and to the cause of advancing technology than to individual companies or industries." These dynamics, so unique to Silicon Valley, created conditions and incentives in which entrepreneurialism would ripen and thrive. "Not only was risk taking glorified, failure was socially acceptable." Saxenian indicates that the typical new start-up in Silicon Valley was formed by a group of engineers with operating experience and technical know-how from having worked together for other firms in the immediate region, joined together by excitement over an innovative idea (Saxenian, 1994).

Saxenian cites several critical factors that drove the entrepreneurial process in Silicon Valley, describing the availability of venture capital, and the characteristics of the venture capitalists themselves, as the engine. "Venture capitalists brought technical skill, operating experience, and networks of industry contacts—as well as cash—to the ventures they funded. Silicon Valley's venture capitalists became unusually involved with their ventures, advising entrepreneurs on business plans and strategies, helping find co-investors, recruiting key managers, and serving on boards of directors." Many of the venture capitalists in Silicon Valley knew one another, forming a loose network of active financial and technical contributors who at times cooperated while at other times competed with one another (Saxenian, 1994).

In addition to the availability of risk-seeking capital, an expanding network of specialist suppliers and service providers contributed to the ascent of Silicon Valley, which allowed firms to specialize on specific product components, freeing them from having to produce a complete product. According to Saxenian: "This independent equipment sector promoted the continuing formation of semiconductor firms by freeing individual producers from the expense of developing capital equipment internally and by spreading the costs of development," while also "reinforcing the tendency toward industrial localization, as most of these specialized inputs were not available elsewhere in the country" (Saxenian, 1994).

Finally, Saxenian cites additional critical variables that increased the energy driving the emergence and dominance of Silicon Valley:

- Professional service firms specializing in problems of technology development, including lawyers, public relations companies, and distributors, many of which were run by individuals in the local technology field, facilitated networking, deal-making, and new business spawning

- Public and private universities in the region, including Stanford University and the University of California at Berkeley, as well as the California state university and community college systems, provided continuing education and training and contracted with local firms to teach private courses for their employees

- Growing number of research labs and branch plants of national technology firms, rendering the area ever more fertile for new business formation by expanding the skilled labor pool, the capacity of shared services, and the intensity of localized communications and debate

- Business associations forged connections between industry and government to help establish public policies that would address concerns and resolve problems.

Saxenian argues that all of these factors created a decentralized industrial system that, rather than leading to fragmentation and vulnerability, actually was securely integrated by these formal and informal practices and methods. "The paradox of Silicon Valley was that competition demanded continuous innovation, which in turn required cooperation among firms" (Saxenian, 1994).

Boston's Route 128

Boston's Route 128, on the other hand, developed an altogether different industrial order. Saxenian describes Boston's Route 128 experience as one of independence and hierarchy, rooted in independent firms that marked the old East Coast establishment. In contrast to the competition and community that has come to characterize Silicon Valley, "secrecy and territoriality ruled relations between individuals and firms, traditional hierarchies prevailed within firms, and relations with local institutions were distant—even antagonistic. The region remained a collection of autonomous enterprises, lacking social or commercial interdependencies" (Saxenian, 1994).

Unlike in Silicon Valley, where entrepreneurs rejected traditional structure and method for more dynamic, unconventional approaches, Boston's Route 128 was shaped by centuries of conservative social and business standards that dated from the 17th century, grounded in the traditions and constraints of Puritan New England. Saxenian suggests that this well-defined social hierarchy, which was characterized by stable communities and families deeply rooted in the region, ensured a strict separation between work and social life among the engineers of Boston's Route 128. "The blurring of social and professional identities and the practices of open exchange of information that distinguished Silicon Valley in the 1960s and 1970s never developed on Route 128." In addition, Saxenian continues, "the social gathering places that were common to Silicon Valley do not appear to have existed on Route 128" (Saxenian, 1994).

Local labor markets and patterns of entrepreneurship likewise developed within these traditional, non-dynamic constraints. Saxenian indicates that "stability and loyalty were valued over experimentation and risk-taking" in the Route 128 region, where "the desired career path was to move up the corporate ladder of a large company with a good reputation." Unlike in Silicon Valley, "Route 128 executives were more likely to consider job hopping unacceptable and express a preference for professionals who were in it for the long term" (Saxenian, 1994).

Also in contrast with Silicon Valley, there were only a few successful entrepreneurs who had taken risks to establish new ventures. Consequently, "risk avoidance became self-reinforcing" and the Boston's Route 128 was able to "provide far fewer opportunities for entrepreneurial learning" in comparison with Silicon Valley. Saxenian cites a study that concluded that, whereas new entrepreneurs in Silicon Valley in the 1970s had worked earlier for multiple firms, the typical entrepreneur on Boston's Route 128 had only one prior work experience before founding a start-up. In addition, many of the firms were direct spin-offs from the Massachusetts Institute of Technology, the founders of which lacked any prior industrial experience (Saxenian, 1994).

Saxenian also describes a venture capital industry on Boston's Route 128 that contrasts sharply with that operating in California as Silicon Valley began to emerge. Rather than managed by entrepreneurs themselves, as was the case in Silicon Valley, the venture capital on Boston's Route 128 was established by traditional investors and managed by professional bankers. Saxenian indicates that the venture capitalists of Route 128 also lacked the operating experience in the technology industry that would enable them to assist a business that ran into problems. Venture capital "lacked internal cohesion or strong ties to local industry." Finally, public and private schools of higher education were not organized to support formation of technological start-ups on Boston's Route 128. Thus, Saxenian concludes that, unlike in Silicon Valley, there was little motivation and an insufficient structure of support on Boston's Route 128 for new business formation (Saxenian, 1994).

Boston's Route 128 was defined by the quest for corporate self sufficiency. As they grew, Saxenian suggests, "local companies built self-contained and vertically integrated structures, just as Silicon Valley firms were experimenting with openness and specialization. The desire for self sufficiency was largely a product of local executives' inherited ideas about how to organize production." Corporations on Route 128 operated with extreme secrecy, islands apart from local society, utilizing a model that one executive dictated "doing virtually everything internally" whereby all components were planned, designed, manufactured, and tested in house. Internal management styles differed dramatically between firms in Silicon Valley and on Boston's Route 128. Firms on Route 128 operated with traditional functional and status divisions, muting communication discouraging information sharing across these traditional divides, effectively failing to emulate the new and more dynamic operational models that contributed to the tremendous fertility for ideas and product in Silicon Valley (Saxenian, 1994).

Lessons Learned from the Two Regional Histories

Saxenian suggests that profound cultural and developmental differences between Silicon Valley and Route 128 led to a reversal of fortunes for the two regions in the rapidly changing and highly volatile semiconductor industry. Despite an initial lead on Boston's Route 128 in total military contracts awarded and overall employment during the 1950s, Silicon Valley claimed the lead on these performance benchmarks in the 1960s, and entirely dominated Route 128 by the 1980s.

Saxenian concludes that the failure of Route 128 producers to maintain their initial lead illustrates the advantages of Silicon Valley's regional network-based system versus the independent firm-based industrial system that characterized Boston's Route 128. "While the Route 128 system—with its emphasis on corporate secrecy, vertical integration, and formal hierarchies—provided the stability that is critical in an environment of volume markets and price-based competition, it was inadequate for the accelerating pace of technological and market change in semiconductors."

Silicon Valley's dense social networks and open labor markets, Saxenian argues, encourage experimentation and entrepreneurship. "Companies compete intensely while at the same time learning from one another about changing markets and technologies through informal communication and collaborative practices; and loosely linked team structures encourage horizontal communication among firm divisions and with outside suppliers and customers." (Saxenian, 1994).

Understanding the U.S. Lead in Biotechnology

In a recent article appearing in the *California Management Review*, Lehrer & Asakawa describe efforts by both Germany and Japan to reduce the overwhelming lead held by the United States in the specific field of biotechnology and the lessons learned from the U.S. experience in comparison with other industrialized countries. Lehrer & Asakawa report that the total number of biotechnology venture companies in the U.S. was more than 1,500 in 2002, while the numbers of such firms were fewer than 400 in both Germany and Japan. On a per capita basis, the U.S. had approximately 6 biotechnology venture companies operating in 2002 per million inhabitants, compared with fewer than 5 such companies per million inhabitants in Germany and fewer than 3 such companies per million inhabitants in Japan (Lehrer & Asakawa, 2004).

The genesis of U.S. dominance in biotechnology venture companies is rooted in the American mobilization for World War II, from 1940-1945. During this period, the federal government began infusing substantial resources and funding into university-based science projects for purposes of advancing discoveries in military technology, triaging government, industry, and universities to assist in the effort to confront a threat to world security. While these linkages became institutionalized in the U.S., the trend in Germany, Japan and elsewhere was to maintain division of purpose between universities and research centers, with the former focused on general education and the latter concentrating on pursuit of specialized areas of science.

The effect of the U.S. trend was to actually encourage entrepreneurialism as universities, in cooperation with private industry, sought external funding to support technical research and development. Lehrer & Asakawa suggest that these cooperative beginnings created the right conditions for university scientists to originate their own ventures, describing science entrepreneurship in the U.S. as an "unplanned, bottom-up" phenomenon. In contrast, Germany and Japan have had to utilize "top-down" strategies to induce or push scientists into commercial activities (Lehrer & Asakawa, 2004).

Lehrer and Asakawa conclude that challenging American dominance in biotechnology is therefore a matter of moving from individu*al* entrepreneurship to the institutional entrepreneurship that so characterizes the American dynamic. While inducing scientists to begin new business ventures is relatively easy, they argue, the work of promoting institutional science entrepreneurship is far more difficult. In the U.S., the federal government actively encourages cooperation between scientists and the private sector. "The top administrators of U.S. universities and medical centers, constantly on the lookout for new revenue sources, are often more like private-sector managers than bureaucratic leaders." Furthermore, Lehrer & Asakawa suggest that the U.S. does not enjoy advantages in either the knowledge or the professionalism of its scientific community; rather, what distinguishes the U.S. from potential pursuing nations is the highly competitive environment itself where success is directly tied with rapid response and substantial effort (Lehrer & Asakawa, 2004).

Appendix G: RESI/Towson University 2001 Incubator Analysis

In the 2001 *Maryland Incubator Impact Analysis*,[120] RESI/Towson University estimated the local economic impacts of tenants and graduates of six Maryland incubators:

- Technology Advancement Program (TAP)
- Maryland Technology Development Center (MTDC)
- Technical Innovation Center (TIC)
- Emerging Technology Center (ETC)
- UMBC High-Tech Business Incubator
- NeoTech Incubator

The study estimates that in 2000, the six Maryland incubators considered had a total employment impact ranging from roughly 2,200 to 6,800 jobs and a total personal income impact ranging from approximately $73 to $225 million. A summary of RESI/Towson University's intermediate results are presented below.

Employment Impacts, Incubator Firms, 2000 (Intermediate Results)

Category	**Direct**	**Indirect**	**Induced**	**Total**
Current Tennant	473	175	356	1,004
Graduate	2,439	601	1,338	4,378

Personal Income Impacts, Incubator Firms, 2000 (Intermediate Results)

Category	**Direct**	**Indirect**	**Induced**	**Total**
Current Tennant	$27,679,159	$7,582,983	$10,592,611	$45,854,754
Graduate	$106,650,619	$24,692,771	$39,553,764	$170,897,154

To estimate economic impacts of potential Montgomery County incubators, SPG extrapolated impacts on a per incubator basis and on a per incubated square foot basis. Personal income impacts were inflated to reflect personal income growth between 2000 and 2004. Adjustments were made to account for the age of incubators, and for Montgomery County-specific factors including density of the existing tech community and human capital attributes.

[120] SPG is quite familiar with the RESI analysis because Anirban Basu, the primary author of this report, was also the primary author of that one.